Issued May 8, 1912.

U. S. DEPARTMENT OF AGRICULTURE,

FOREST SERVICE—BULLETIN 96.

HENRY S. GRAVES, Forester.

(IN COOPERATION WITH THE CONNECTICUT AGRICULTURAL EXPERIMENT STATION, E. H. JENKINS, DIRECTOR.)

# SECOND-GROWTH HARDWOODS IN CONNECTICUT.

BY

EARL H. FROTHINGHAM,

FOREST ASSISTANT.

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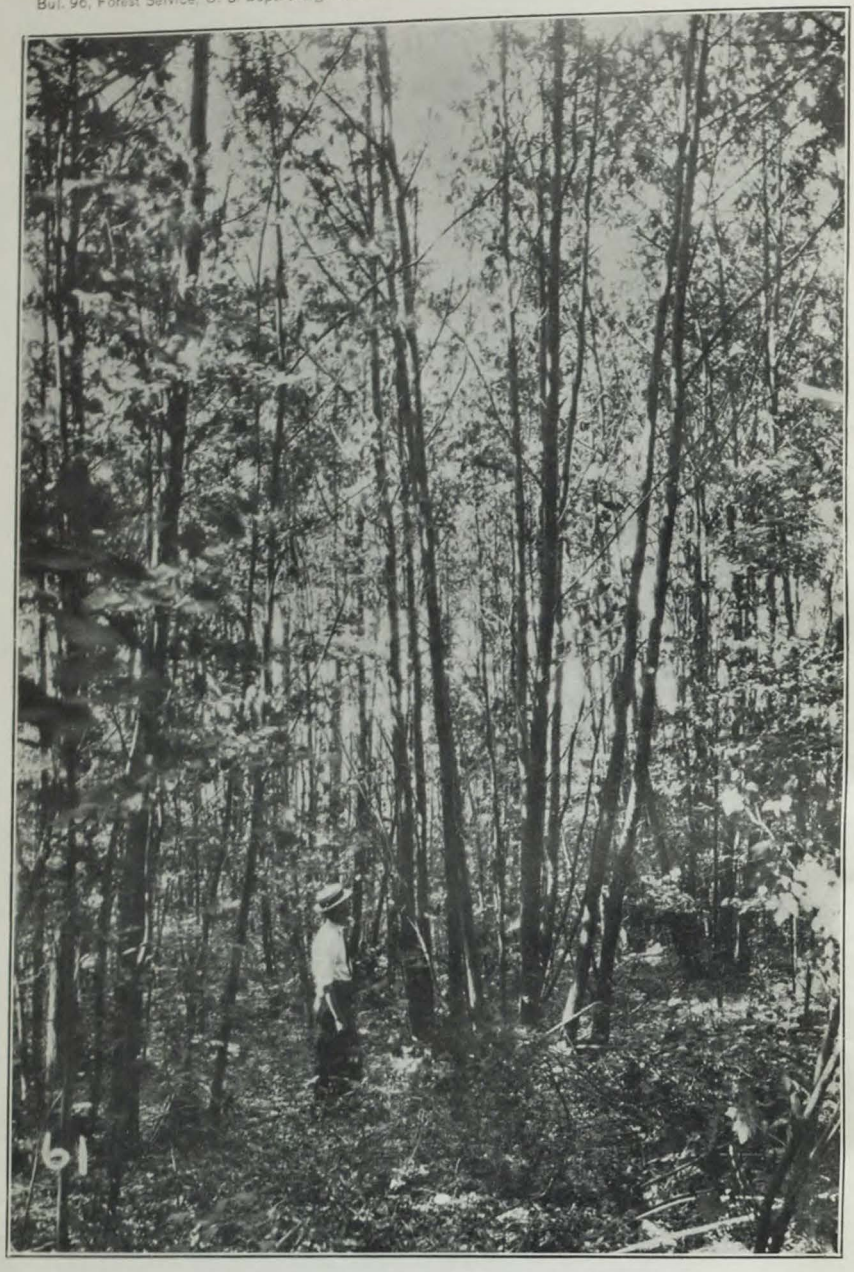
U. S. Forest Service
Rocky Mountain Forest and Range
Experiment Station

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1912.




A 19-YEAR-OLD STAND OF QUALITY I CHESTNUT SPROUTS, WEST CHESHIRE. YIELD ABOUT 25 CORDS PER ACRE.

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# LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Forest Service,
*Washington, D. C., December 19, 1911.*

Sir: I have the honor to transmit herewith a manuscript entitled "Second-Growth Hardwoods in Connecticut," by Earl H. Frothingham, forest assistant, and to recommend its publication as Bulletin 96 of the Forest Service. The study upon which the report is based was made by the Forest Service in cooperation with the Connecticut Agricultural Experiment Station.

Respectfully,

Henry S. Graves,
*Forester.*

Hon. James Wilson,
*Secretary of Agriculture.*

# CONTENTS.


| | Page. |
|---|---|
| Scope of the study | 9 |
| Part I.—Present forest conditions in Connecticut | 10 |
| Forest resource | 10 |
| Topography, climate, and soil | 11 |
| Connecticut woodlands | 12 |
| Second-growth types | 12 |
| White pine | 12 |
| Old field type | 12 |
| Even-aged hardwoods | 13 |
| Part II.—Market and stumpage | 14 |
| Selling timber "by the lot" | 14 |
| Market values and uses of native forest products | 15 |
| Lumber, by species | 15 |
| Ties | 17 |
| Poles | 18 |
| Cordwood | 19 |
| Piles, posts, and rails | 19 |
| Logging costs | 20 |
| Lumber | 20 |
| Ties | 21 |
| Poles | 22 |
| Cordwood | 23 |
| Value of standing timber | 24 |
| Basis of value | 24 |
| Lumber | 25 |
| Ties | 26 |
| Poles | 28 |
| Cordwood | 29 |
| Part III.—Yield of even-aged hardwood stands | 30 |
| Factors which influence the yield | 30 |
| Types | 30 |
| Quality classes | 31 |
| Growing stock | 31 |
| Yield tables | 34 |
| General | 35 |
| Cordwood | 38 |
| Lumber | 39 |
| Ties | 40 |
| Poles | 41 |
| How to use the yield tables | 41 |
| Growth of stands | 42 |

Page.
Part IV.—Management ..... 44
Choice of species ..... 44
Factors influencing rotation ..... 45
Method of reproducing the stand ..... 45
Choice of material ..... 46
Culmination of the average annual growth ..... 48
Greatest income ..... 49
Thinnings ..... 49
Object of thinnings ..... 49
Time and severity ..... 50
Trees removed ..... 51
Results of thinnings ..... 52
Final cutting and reproduction ..... 54
Clear-cutting system ..... 54
Pole-wood sprout system ..... 55
Changing the type ..... 56
Regenerating worn-out sprout stands ..... 57
Protection ..... 58
Financial returns ..... 58

APPENDIX.

Volume tables ..... 61
Cubic feet ..... 61
Cordwood ..... 63
Lumber ..... 64
Ties ..... 66
Poles ..... 67
Yield of individual oak and oak-chestnut stands ..... 68

# ILLUSTRATIONS.

PLATES.


Page.

A 19-year-old stand of quality I chestnut sprouts ..... Frontispiece.

PLATE I. Fig. 1.—Typical clean cutting for cordwood in first quality rock-oak (ridge) type. Fig. 2.—Dense white pine reproduction ..... 16

II. Fig. 1.—Thirty-seven-year-old stand of quality II chestnut. Fig. 2.—Fifty-year-old stand of quality I chestnut ..... 32

III. Fig. 1.—Stand of chestnut sprouts and seedlings, 90 to 100 years old. Fig. 2.—Moderate thinning in 35-year-old quality I chestnut ..... 48

IV. Fig. 1.—Forty-five-year-old quality II chestnut stand before thinning. Fig. 2.—Same stand after thinning ..... 48

V. Fig. 1.—Forty-five-year-old chestnut stand, quality III, before thinning. Fig. 2.—Same stand after heavy thinning ..... 56

VI. Fig. 1.—Forty-five-year-old stand of chestnut oak, quality III, before thinning. Fig. 2.—Same stand after thinning ..... 56


TEXT FIGURES.


FIG. 1.—Height growth of dominant trees, chestnut type ..... 32

2.—Basal area per acre for three quality classes, chestnut type ..... 33

3.—Yield per acre for three qualities in chestnut, oak-chestnut, and oak types ..... 34

# SECOND-GROWTH HARDWOODS IN CONNECTICUT.

## SCOPE OF THE STUDY.

In dealing with forests among the essential things to know are the rate at which they grow, the value of the standing timber for different uses, and the method of management which will give the maximum yield of most valuable material in the shortest time. To tell these things for the forests of Connecticut, especially for the predominating types—second-growth chestnut, oak, and mixed hardwoods—is the purpose of this bulletin. The results given were derived from field work carried on by the Forest Service during the summer of 1910, in cooperation with the Connecticut State forester, Mr. S. N. Spring. As a means of preparing yield tables for second-growth hardwood stands, which would show the number of cords, ties, poles, or board feet of lumber obtainable from stands of different qualities at the end of any given number of years, more than 250 sample plots, aggregating about 65 acres, were laid out in even-aged stands at various places throughout the State, the trees carefully measured, and the total volumes determined. For determining these last, volume tables for oak and chestnut were prepared from measurements of the actual contents of 400 felled trees, together with 552 similar measurements previously made in adjacent portions of New York by Mr. J. G. Peters, of the Forest Service. Information was also gathered concerning the prevailing market conditions and the costs of logging, from stump to market, for all the principal products of Connecticut woodlots. From this information an attempt has been made to derive reasonable stumpage values, which would prove more just to owner and purchaser alike than the haphazard methods of sale now commonly in use. These values approximate an average for the State, and would not necessarily apply to any specific timberland. No such general calculations could, in fact, take account of all the varying factors which enter into the computation of stumpage value in any given instance. They should serve, however, to illustrate a practical method of arriving at the true present market values of forests.

Data were secured in regard to the effect of thinning to increase the rate of growth, and permanent sample plots were established in which the growth in thinned and unthinned stands can from time to time be accurately measured and compared.

The chestnut-bark disease, now so prevalent in Connecticut, presents a serious problem to owners of woodlands. Although it must, of course, be reckoned with in the management of stands containing chestnut, no detailed discussion of it is attempted in this bulletin. For information on the disease readers are referred to Farmers' Bulletin 467, of the U. S. Department of Agriculture, "The Control of the Chestnut-Bark Disease."

Part I of the bulletin deals briefly with present forest conditions in Connecticut; Part II considers market conditions, logging cost, and the value of standing timber; Part III, the yield of different types and qualities of forest; and Part IV methods of management. The Appendix contains volume tables for oak and chestnut.

## PART I.—PRESENT FOREST CONDITIONS IN CONNECTICUT.

### FOREST RESOURCE.

Few of Connecticut's resources have compared in usefulness with its forests. Not only have they yielded directly a great and increasing quantity of railroad ties, telephone and telegraph poles, lumber, and other products, but indirectly they have been perhaps the chief factor in the success of some of the State's most valuable industries. One of these, brass manufacture, owes its present supremacy largely to the cheap, abundant, and constant supply of wood fuel. Lime and charcoal burning, brick manufacture, and other important industries have in like manner profited from the forest. An immense amount of firewood is used annually for household consumption.

Compared with the production of fuel wood, the lumber output of Connecticut is remarkably small. Thus, in 1908, while the lumber cut amounted to 137,855,000 board feet, valued at $2,352,186, the total firewood consumption in the State was estimated at 495,370 cords, which, at an average price of about $4.45 per cord, had a value of $2,204,805. Assuming 2 cords to the 1,000 board feet—a conservative equivalent—the fuel wood consumption is comparable to a lumber cut of 247,685,000 board feet. It is thus apparent that while the cordwood cut was almost 80 per cent greater than the lumber cut, its actual value was about 6½ per cent less. The drain put upon the forest for cordwood is far in excess of that for all other uses combined.

It is not, however, in the mere quantity of wood removed that this drain is most serious. Almost all of the cordwood cut consists of small and rapidly growing trees, of relatively small present worth, but capable of furnishing within comparatively few years poles, lumber, or other products of greater value than cordwood or even than ties. Disregard of this potential value of the forest inevitably results

in wasteful use, and deprives State and owner of the just returns on their woodland investments.

Connecticut, like most of the other Northeastern States, imports much the greater part of its lumber. The sources from which this is obtained are themselves rapidly becoming depleted, and with the advancing lumber prices which mark this decline the home production of lumber will increase in attractiveness to timberland owners.

## TOPOGRAPHY, CLIMATE, AND SOIL.

The productive capacity and consequently the value of Connecticut forests are to a great extent dependent upon the topography, soil, and climate of the State. A general idea of these is necessary before the producing value of the woodlands, which varies with the character of the situation, can be clearly discussed.

Connecticut may be briefly described as a broad, central lowland, extending in a general north-and-south direction, and limited on the west and east by high and often steep ridges and ranges of hills, southward extensions of the great highland region of northern New England. At places throughout the plain there are precipitous dikes of trap rock, which rise conspicuously above the general level. In altitude the central valley lies mostly below 100 and 200 feet, except for the trap dikes, which in some cases rise to 700 feet. The eastern highland rarely exceeds 500 feet in altitude. Along the western ridge, however, elevations range in the south from sea level to 500 feet and farther north from 1,000 to over 2,000 feet at the tops of ridges and peaks. The greater part of the State is drained by three large river systems—the Housatonic, with its tributary, the Naugatuck, in the western highland, the Connecticut in the central valley, and the Thames in the east.

The soils are mostly of glacial origin, and present a great variety of conditions. In the highlands every degree of fertility, from shallow, stony, untillable land to sandy or clayey loam of high productive value, may often be found within a small area. Except in the central valley the soils are almost universally rocky, a condition which greatly lowers the agricultural value of otherwise fertile land. In the highlands the best soils are on the tops of ridges, where there are often wide stretches of exceedingly productive farm land. In the central valley also the soil is for the most part fertile and produces excellent crops of tobacco, grains, and fruits. Over one-third of the State, however, is unsuitable for agriculture, either through poor soil or broken and steep topography.

The climate of Connecticut is moderate. Late spring frosts often damage the fruit crops, but winter temperatures are not, as a rule, excessive. The annual rainfall amounts to about 47 inches.

## CONNECTICUT WOODLANDS.

The woodland and brush area of Connecticut is estimated to be nearly one-half the total area of the State, or about 2,500 square miles. Practically the whole of the woodland has been cut over repeatedly. Along the northern border there still exist a few small virgin stands of white pine and one excellent stand, only 200 or 300 acres in extent, of hemlock, maple, beech, yellow birch, and other northern hardwoods. But aside from these the present forests of Connecticut have sprung up after the removal of the original virgin stands, or after the abandonment of farm lands, and are known as "second growth." This term is of course a misnomer, since the stands are rarely the second, but often the third, fourth, or even farther removed crops from the original forests. The term has gained sanction by common usage, however, and will be used in this report to mean any stand, however old, which has sprung up after lumbering, clearing for agriculture, or fire since the first settlement of the State.

## SECOND-GROWTH TYPES.

The second-growth stands may be divided into swamp types and upland types. The swamp types may further be divided into hardwood types and a cedar type. The hardwood swamp types contain ash, elm, maple, black gum or "pepperidge," swamp white oak, yellow poplar or "whitewood," and other valuable moisture-loving species. The cedar type is so named from the presence of white cedar (*Chamæcyparis thyoides* (L.) B. S. P.), either in pure stands or in mixture with other species. Although often valuable locally, these types occupy a relatively small portion of the forest area and will not be considered in this study.

The upland second-growth types comprise three distinct classes—(1) white pine, (2) old field, and (3) even-aged hardwoods.

### WHITE PINE.

Second-growth white pine stands are quite numerous, especially in the northern and eastern portions of the State. They are usually dense and even-edged, and result from the seeding of abandoned fields by white pine trees in the vicinity. There are also many plantations of white pine in the State, a few of which have already reached merchantable size. Though very limby, second-growth pine is already valuable and promises to become more so, especially for box boards.

### OLD FIELD TYPE.

As its name implies, this type results from the seeding of abandoned fields by various trees, but chiefly gray birch and red cedar. These two species are, as a rule, the advance forest growth over old

fields, with birch more conspicuous in some places and cedar in others. Sooner or later other and more valuable species begin to appear beneath or between them, and, if left alone, the forest ultimately develops into the prevailing mixed hardwoods type. Since the reforestation of an abandoned field rarely becomes complete in less than 50 or perhaps 100 years, the resulting stand is of very uneven age. All stages in the transition from field to merchantable forest may be found: First, the advance growth of birch, cedar, and shrubs of various kinds; then crowded mixtures of these with young trees of more shade-enduring species, fighting vigorously for light and growing space; and, finally, the stand of oaks and chestnut. Once cut over, this becomes the characteristic even-aged woodland.

### EVEN-AGED HARDWOODS.

Even-aged hardwoods may be termed the characteristic forest of Connecticut. These types are, from the standpoint of forestry, at once the most valuable and the most interesting in the State. From them, all but a small portion of Connecticut's domestic wood supply is obtained. The tree above all others which has contributed to this production is chestnut. Fully one-half of the standing timber in Connecticut is of this species. Chestnut is practically the only tree in the State used for telegraph and telephone poles; it furnishes the greater part of the supply of railroad ties; and is the principal source of firewood. Next to it in importance are the oaks, principally the black oaks. Among the other species which, in less abundance, enter into these types are hickory, red maple, white ash, and, of less importance, aspen, cherry, butternut, and basswood.

The value and, in fact, the very existence of second-growth hardwood stands depends largely upon the prolific sprouting capacity of the species which compose them. Much the greater part of the present Connecticut forests originated from sprouts. This is particularly true of chestnut. Indeed, there is reason to believe that the amount of chestnut in Connecticut has increased since cutting began, chiefly through its prodigious sprouting capacity combined with its rapid growth.

One of the most striking features of these types is their evenness of age. This is the result of the common practice of clean cutting, together with abundant sprouting capacity. Where there is a cordwood market, lumber, tie, or pole operations are usually followed by cordwood choppers, who utilize the logging waste and the smaller trees left by the loggers, and thus complete the total removal of the stand. During the ensuing spring, provided no fire occurs, practically every chestnut stump and most of the smaller stumps of oak and other species send up quantities of rapid-growing sprouts, which, in the course of five or six years, close together and form a

more or less uniform crown canopy. Since oak and chestnut do not stand shade well, the shorter trees which are shaded by their neighbors soon begin to die out. As the survivors increase in size they decrease in number, and it is always the larger trees, whose crowns still receive plenty of light, which continue to develop. Sprout stands of chestnut and oak do not cast a heavy shade, and usually admit to the forest floor enough light to maintain an understory of such shade-enduring trees as red maple, black birch, hickory, and beech, and numerous shrubs. As a rule, however, the trees grown in such shade are slender and too poorly developed to succeed if the main stand of chestnut and oak were removed. Chestnut and black or red oak reproduction is impossible under the normal shade of the older stand, and although seedlings and sprouts may appear, they are unable to attain merchantable size, except in chance openings in the crown canopy. This, and the rapid production of even-aged sprout stands, make clear cutting the rule among owners of Connecticut woodland.

The ordinary logging operation in Connecticut, however, involves much waste which might easily be avoided. This occurs not only in the failure to utilize all the usable portion of the stand after it is felled, though this is only too often the case, but in the loss through natural death and decay of the trees killed out in the competition for light and growing space. By systematic thinnings at intervals of 5 or 10 years, after the stand has become of merchantable size for cordwood, this loss not only can be almost entirely prevented, but the growth of the remaining trees can be greatly accelerated and the yield of the stand increased both in quantity and in quality.[1] There is also danger of waste through ignorance of the producing capacity of a woodland and failure to decide upon the most remunerative product for exploitation.

## PART II.—MARKET AND STUMPAGE.

### SELLING TIMBER "BY THE LOT."

The average woodlot owner of Connecticut has only a vague idea of the actual value of his timber. His sales are usually made "by the lot," and he receives a lump sum for all the timber on a given area with little regard to the exact amount and value of the different products obtainable. Not only are both owner and purchaser in many cases ignorant of even the approximate yield per acre, but they fail to consider probable expense of logging and manufacture. A striking example of loss to the owner which may be entailed by such haphazard methods is that of a sale six or eight years ago of a "lot" of virgin hardwoods for $2,200. The purchaser cut from it

[1] Objects and methods of thinnings in mixed hardwood stands are discussed in Part IV of this bulletin.

white oak which brought him $2,000, held the land four or five years, and finally sold it for over $10,000. Doubtless this is an extreme case, but there are many which, while not involving as large an amount of profit and loss, have yet failed to net the owner anything like the true value of his timber.

The sale value of timber, as of any other raw material, is the market value of the finished product less the cost of production and a reasonable profit. In the following chapters of this part of the bulletin there will be discussed the market value of the various products of Connecticut forests, the costs of getting them from the stump to the market, and derived from these two factors the approximate value of the standing timber (stumpage value) for each of its principal uses.

## MARKET VALUES AND USES OF NATIVE FOREST PRODUCTS.

### LUMBER, BY SPECIES.

The amount of lumber annually brought into Connecticut from other States greatly exceeds the annual cut in the State itself. Yellow pine from the South, cedar and fir from the Pacific coast, and white pine and spruce from northern New England form the bulk of the imports, though a considerable amount of hardwoods, including chestnut and oak, is also brought in.

In 1909 the lumber cut for Connecticut exceeded that for any previous year of which there is record. Table 1, compiled by the Bureau of the Census, gives the production of lumber in that year by species.

TABLE 1.—*Lumber cut of Connecticut, 1909.*

| | Board feet. | | Board feet. | | Board feet. |
|---|---|---|---|---|---|
| White pine | 30,579,000 | Oak | 34,246,000 | Cherry | 159,000 |
| Hemlock | 11,177,000 | Maple | 3,924,000 | Butternut | 60,000 |
| Yellow pine | 2,152,000 | Hickory | 2,442,000 | Tupelo (black gum) | 54,000 |
| Spruce | 262,000 | Ash | 1,684,000 | Sycamore | 10,000 |
| Cedar | 78,000 | Birch | 1,361,000 | | |
| Balsam fir | 1,000 | Beech | 804,000 | Total hardwoods | 124,122,000 |
| | | Basswood | 745,000 | | |
| Total softwoods | 44,249,000 | Cottonwood | 476,000 | Total | 168,371,000 |
| | | Elm | 367,000 | | |
| Chestnut | 77,604,000 | Walnut | 186,000 | | |

Chestnut, it will be seen, comprises over 46 per cent and oak over 20 per cent of the total cut, while they, with white pine and hemlock, form more than 91 per cent of the total.

The following are the principal uses and market values for six of the leading kinds of lumber cut in the State:

*Chestnut.*—Native chestnut lumber is used very largely for bridge and car construction and in building. It also finds use as interior finish, furniture, molding, and cabinetwork. Because chestnut is so

extensively used for poles, ties, planks, and heavy short timbers, cabinet manufacturers and others using finishing lumber find it well-nigh impossible to obtain seasoned and well-graded stock of sufficient length for their needs and are compelled to import their chestnut, often from distant points. This inability to obtain domestic lumber in proper size and quality is due largely to the owners of wood lots, who prefer to supply the constant demand for cordwood, ties, and switch timbers rather than to grow higher-class material for a less certain market. Lumber is usually a secondary consideration. That which they cut is usually in short lengths, ungraded, unseasoned, and likely to be narrow or knotty. It is sometimes hard to dispose of such material for $14 per thousand board feet. Much excellent stuff is cut, however, in the form of short bridge planking and car stock.

The ordinary wholesale values for native chestnut lumber and planks range from $18 to $25 per thousand board feet. Extra wide and long lumber brings a much higher price, and by grading and seasoning it is more than likely that $40 could be obtained for chestnut lumber in New York, if not in Connecticut. From the development of such a market another for the lower grades could be expected. Hitherto these have too often proved a drug on the market sufficient to nullify the highest prices received for the best grades.

*Oaks.*—Oak timbers are widely used in car construction for head sills, bumpers, and box-car frames, and the like, for which their superior strength adapts them. For main sills southern yellow pine is used, since oak of sufficient length can rarely be obtained in the State. Oak plank is in demand for wagon stock and steamer paddle box buckets. Oak is the principal wood used in wheel manufacture, and it also finds place for furniture, interior finish, handles, picker sticks for looms, and a number of other purposes. Because of its wider usefulness, oak lumber has a higher market value than chestnut. In general, it brings from $25 to $35 per thousand board feet, although short car oak ordinarily ranges from $24 to $20, and even less, per thousand. White oak is, of course, much the most valuable species; $30 per thousand feet is probably about the average wholesale price for white-oak planks and lumber, though dealers often receive as much as $40 or $45 per thousand for the best white oak plank up to 18 feet in length. "Rock" or chestnut oak lumber, which closely resembles white oak, is somewhat less valuable than the latter. For "yellow" or black oak and red oak lumber, $25 per thousand is about the average.

*White pine.*—White pine lumber, unedged, knotty, and in short lengths and small sizes, finds a market as box boards, and brings from $12.50 to $16 per thousand wholesale. Square-edged white pine lumber usually sells wholesale for from $20 to $30 per thousand.

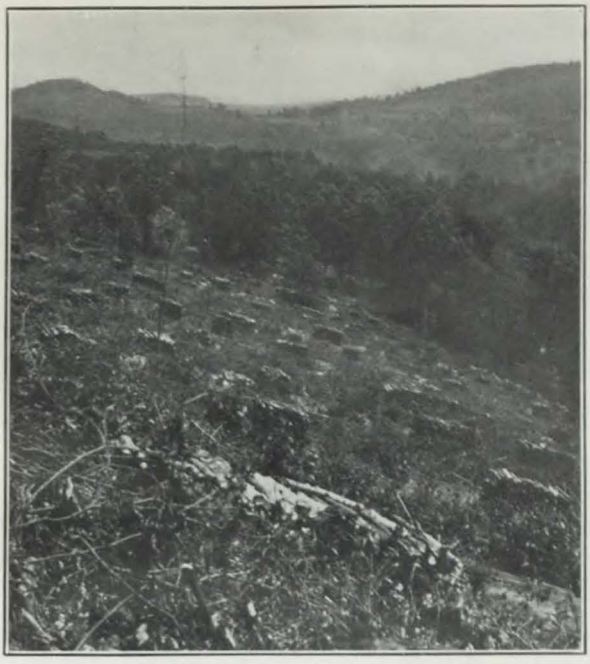

FIG. 1.—TYPICAL CLEAN CUTTING FOR CORDWOOD IN FIRST QUALITY ROCK OAK (RIDGE) TYPE.

FIG. 2.—DENSE WHITE PINE REPRODUCTION IN OPENING IN STAND OF MIXED PINE AND HARDWOODS.

*Hemlock.*—The cut of hemlock in the State is relatively small and unimportant. Much of it is used locally for general construction purposes. Retailed it brings from $17 to $26 per thousand board feet. A small amount of hemlock bark is consumed in the State for tanning.

*Ash.*—Ash is used for wagon stock, picker sticks for looms, furniture, hockey sticks, rake and shovel handles, and the like. It is bought by factories for from $25 to $30 per thousand, though it occasionally retails as low as from $20 to $22.

*Hickory.*—Nearly all the hickory used in Connecticut for carriage spokes is imported, since the native timber is too small and too limby for the purpose. For automobile spokes, however, it finds a ready market, and factories buy it in the form of short-spoke bolts or in plank, paying usually from $30 to $40 per thousand. Native hickory is also manufactured into hockey sticks, tool handles, and picker sticks for looms.

## TIES.

The market for crossties in Connecticut is remarkably steady. Ties are purchased by railroads at any point along their rights of way, which often very materially shortens the length of haul. The New York, New Haven & Hartford Railroad in its published specifications, dated January 1, 1909, distinguishes three classes of 8-foot ties, "Class I," "Class II," and 7 by 9 inch ties. In addition, 7 by 9 inch switch timbers, sawed square, are purchased in lengths designated in special orders.

Class I and Class II ties must be of chestnut or of white, "yellow" (black), or "rock" (chestnut) oak. Class I ties, if sawed on all four sides, must have at least 8 inches face and 6 inches thickness; if flattened on only two sides, they must have 6 inches or over face and be 6 inches thick. In the first case they obviously contain 32 board feet apiece and run 31¼ to the thousand board feet. If flattened on only two sides, with 6 inches face, the Class I tie contains a little over 30 board feet, and about 33 ties are equivalent to a thousand board feet of lumber. The railroad pays 50 cents apiece for first-class ties, a price equivalent to about $16 per thousand board feet.

Class II ties must have not less than 5 inches face and 6 inches thickness, and must not exceed 10 per cent of the total number of Class I ties accepted. Flattened on two sides they ordinarily contain less than 27 board feet and run about 38 to the thousand. They bring 30 cents apiece, or about $11.40 per thousand board feet.

The heavy 7 by 9 ties must be of chestnut, 7 by 9 inches square if sawed on all four sides, or with 7 inches face and 7 inches depth if sawed or hewed on only two sides. If square, such ties contain 42 board feet apiece and run about 23.8 to the thousand. If flattened

on only two sides they contain about 37.7 board feet, and run about 26.5 to the thousand. They bring 72 cents apiece, a price, assuming them to contain an average of 40 board feet, equivalent to $18 per thousand.

Switch timbers must be of chestnut and be sawed on all four sides. In 8-foot lengths they would be identical with 7 by 9 inch ties sawed on all four sides. They are purchased by the thousand board feet and must be loaded on cars and invoiced like ordinary lumber. At present their usual price is $20 per thousand board feet.

### POLES.

A fairly steady market for poles is offered by telephone, telegraph, and electric power companies. Poles must be of sound, well-proportioned chestnut, reasonably straight, without unsound knots, and with all knots trimmed close. They are purchased on the basis of length up to a circumference of 22 inches (diameter of 7 inches) and must conform to the specified circumference from 5 to 6 feet from the butt. Some of the pole-using companies publish price lists for poles of specified sizes, while others arrange prices with individual owners or contractors.

The prices offered for poles vary considerably from year to year. Between 1906 and 1909 the average price paid for poles by one company showed a steady increase of 35 per cent. The average prices paid for poles of different lengths by this company in 1909 were approximately as follows:

| | | |
|---|---|---|
| 20 feet long..... $1.20 | 35 feet long..... $4.10 | 50 feet long..... $9.00 |
| 25 feet long..... 1.90 | 40 feet long..... 5.30 | 55 feet long..... 12.10 |
| 30 feet long..... 3.00 | 45 feet long..... 6.90 | 60 feet long..... 15.00 |

It is probable that over 90 per cent of all poles used in the State are under 40 feet in length. Contractors often obtain poles for prices considerably less than those just quoted, especially in localities which, in the owner's opinion, are too far from market to make other kinds of logging profitable, but where the poles can be delivered along trunk lines close to the woods with but a short haul. Thus, 35-foot poles are sometimes sold for from $2.20 to $1.75, or even less. In some places $1.50 is considered a standard price for a 25-foot pole, and $1 is added for every 5 feet in addition up to 40 or 45 feet. At Putnam, in the northeastern part of the State, the price of poles delivered ranges about as follows:

| | |
|---|---|
| 25 feet long..... $1.00 to $2.00 | 40 feet long..... $4.25 to $5.00 |
| 30 feet long..... 2.25 to 3.00 | 45 feet long..... 5.75 to 6.50 |
| 35 feet long..... 3.25 to 4.00 | |

In this report the prices first quoted will be used, since they represent a fair average of the maximum prices prevailing at present.

### CORDWOOD.

Cordwood has a smaller market value, volume for volume, than any other of the principal forest products. Although it is used for fuel all over the State and markets for it exist in all the larger towns and cities, it is so abundant that the sale price often barely covers the cost of getting it to market. Except near large towns, a haul of 5 or 6 miles is usually sufficient to make cordwood cutting unprofitable. The annual waste of good cordwood material in tops and limbs left in the woods after the removal of lumber, ties, and poles is often enormous. In one case this loss was estimated at 10,000 cords per year for an area less than 10 miles square.[1]

Much of this waste can be avoided by coaling the wood in the forest, when the reduced weight of the charcoal permits of longer hauls with profit. Charcoal burning has declined of late years, because of the large substitution of coke for fuel in iron manufacture and of the importation of charcoal from other States. In many parts of Connecticut, however, charcoal burning still goes on, chiefly at points too far from market for cordwood to be hauled profitably.

The principal species used for cordwood are chestnut, oaks, maple, hickory, and gray birch. Of these, hickory has the highest fuel value, and near cities sometimes sells for from $7 to $8 per cord wholesale, cut in 4 or 5 foot lengths. Birch is ordinarily of little value because of its liability to decay and brings a price of from $3 to $4 per cord. It is excellent, however, for burning in open fireplaces, and sometimes sells for as much as $7. Maple, chiefly "soft," "swamp," or red maple, sells at from $3.25 to $4.75 per cord wholesale, oak at from $3.50 to $5, and chestnut at from $3 to $4.25. "Mixed hardwoods," mostly oak and maple, usually bring from $3.50 to $4.75 wholesale. Wood delivered directly to the consumer brings more, of course, than when sold to dealers.

### PILES, POSTS, AND RAILS.

Its durability makes chestnut the species best suited for piles, posts, and rails, though other species are also used. Piling is sold by the running foot to an upper diameter of 7 inches. Twenty cents per running foot is the common price for 40 to 45 foot piles, though buyers sometimes succeed in getting them for as little as 14 cents. Specifications for fence posts usually call for chestnut, sound and free from shakes and rotten knots, 7½ to 8 feet long, with 6 inches top diameter, and with bark removed. They sell at from 14 to 35 cents apiece in different portions of the State. Railing commands about 3 cents per running foot, delivered at side of road. It is used to a diameter at the smaller end of about 4 inches.

[1] Bulletin 162, Connecticut Agricultural Experiment Station, Forest Survey of Litchfield and New Haven Counties, p. 22.

## LOGGING COSTS.

The term "logging costs" as used in this bulletin is meant to include the costs of exploitation from the stump to the market. The strict meaning of the term logging is here extended to cover not only the costs of cutting and hauling logs, but also the costs of sawing lumber, of cutting cordwood, poles, and ties, and of hauling all classes of products to the market. The most variable cost is that of hauling. This varies both with the amount of material that can be hauled per day and with the rate of wages. The amount of material which can be hauled per day depends upon the distance between the woods and the market, upon whether the wood is green or seasoned, and upon the character of the topography, the condition of the roads, etc. In arriving at the costs given in Table 2 it was assumed that an ordinary team of draft horses will not, if used daily, exceed an average of 18 miles—one-half of the distance with a loaded wagon—over average roads. The wages of team and driver ordinarily vary from $4 to $5.50 per day. In Table 2 the costs of hauling have been computed for different wage rates and distances. The average wagon-load is assumed to be any one of the following: 1,000 board feet of lumber, 32 first class ties, one cord of 4 foot wood, six 25 to 30 foot poles, four 30 to 35 foot poles, or two 35 to 45 foot poles.

TABLE 2.—*Costs of hauling, with different wage rates and daily hauling capacities.*

| Daily hauling capacity for 1 team. | Wage rate. | | | |
|---|---|---|---|---|
| | $4.00 | $4.50 | $5.00 | $5.50 |
| | Hauling cost per load. | | | |
| 1 load | $4.00 | $4.50 | $5.00 | $5.50 |
| 2 loads | 2.00 | 2.25 | 2.50 | 2.75 |
| 3 loads | 1.33 | 1.50 | 1.67 | 1.83 |
| 4 loads | 1.00 | 1.13 | 1.25 | 1.38 |
| 5 loads | .80 | .90 | 1.00 | 1.10 |

## LUMBER.

By far the greater part of the lumber sawed in Connecticut is the product of small portable mills of 10,000 or 15,000 board feet daily capacity, but which produce on an average not over 6,000 or 8,000 board feet per day. Mills such as these can ordinarily be moved for $40 or $50, and a stand of 75,000 or 100,000 board feet will warrant a set-up.

The costs of lumbering as given in Table 3 include falling, skidding or "drawing in," sawing, and piling or loading on cars at the destination, but not hauling. Each of these costs is somewhat variable, and minimum, average, and maximum costs are given.

TABLE 3.—*Costs of lumbering (except hauling) per thousand board feet.*

| | Minimum. | Average. | Maximum. |
|---|---|---|---|
| Cutting | $1.25 | $1.50 | $2.00 |
| Skidding | 1.50 | 1.75 | 2.00 |
| Sawing | 2.50 | 3.50 | 4.00 |
| Piling | 1.00 | 1.00 | 1.00 |
| Total (except hauling) | 6.25 | 7.75 | 9.00 |

By combining the costs in Tables 2 and 3, the approximate total costs of logging and hauling given in Table 4 are obtained. Since an estimate of costs is not complete without including interest on the money which would have to be invested in the operation, the last column shows approximately the total average cost per thousand board feet of logging and hauling lumber computed at 6 per cent for one year.

TABLE 4.—*Total cost per thousand board feet of logging and hauling lumber, with and without interest charges.*

| Daily hauling capacity for 1 team. | Teaming wage rate per day. | Total cost per 1,000 board feet. | | | Average total cost with interest per 1,000 board feet. |
|---|---|---|---|---|---|
| | | Minimum. | Maximum. | Average. | |
| 1,000 board feet | $5.50 | $11.75 | $14.50 | $13.25 | $14.05 |
| | 5.00 | 11.25 | 14.00 | 12.75 | 13.52 |
| | 4.50 | 10.75 | 13.50 | 12.25 | 12.98 |
| | 4.00 | 10.25 | 13.00 | 11.75 | 12.46 |
| 2,000 board feet | 5.50 | 9.00 | 11.75 | 10.50 | 11.13 |
| | 5.00 | 8.75 | 11.50 | 10.25 | 10.87 |
| | 4.50 | 8.50 | 11.25 | 10.00 | 10.60 |
| | 4.00 | 8.25 | 11.00 | 9.75 | 10.34 |
| 3,000 board feet | 5.50 | 8.08 | 10.83 | 9.58 | 10.15 |
| | 5.00 | 7.92 | 10.67 | 9.42 | 9.98 |
| | 4.50 | 7.75 | 10.50 | 9.25 | 9.81 |
| | 4.00 | 7.58 | 10.33 | 9.08 | 9.63 |

## TIES.

The cost of tie production varies chiefly with the distance of haul, but also with the method of manufacture. To hew ties usually costs from 9 to 10 cents apiece for chestnut and 12 cents for oak. Ties should be sawed at less cost per thousand feet than lumber, because there is less labor involved in sawing out large pieces and less waste in kerf. Ties sawn on only two faces are much cheaper to produce than are those sawn on four sides. Assuming 33 first-class or 38 second-class ties to the thousand board feet, the costs of logging, exclusive of hauling, are about as given in Table 5.

TABLE 5.—*Cost of tie production (except hauling) per 1,000 board feet.*

| | Minimum cost per 1,000. | Average cost per 1,000. | Maximum cost per 1,000.[1] | Cost per tie. | | Hewing per 1,000. |
|---|---|---|---|---|---|---|
| | | | | First class. | Second class. | |
| Cutting | $1.00 | $1.50 | $2.00 | $0.031–$0.063 | $0.026–$0.053 | ..... |
| Drawing to mill | 1.00 | 1.75 | 2.00 | .031– .063 | .026– .053 | ..... |
| Sawing | 1.75 | 2.00 | 4.00 | .055– .125 | .046– .105 | ..... |
| Peeling | .35 | .35 | ..... | .01– .01 | .01– .01 | ..... |
| Total | 4.10 | 5.60 | 8.00 | .127– .261 | .108– .221 | $3–$4 |

[1] The maximum cost involves sawing ties on four sides, which increases the cost of sawing and dispenses with that of peeling.

From 25 to 40 ties, depending upon the character of the haul, make an ordinary wagonload; usually about 33 first or 38 second class ties (equivalent to 1,000 board feet) can be hauled at one trip. Adding the total costs per thousand in Table 5 to the costs of hauling at various wage rates in Table 2, gives the total cost for ties delivered at the railroad, as shown in Table 6. The total average cost per thousand feet, with interest at 6 per cent for one year added, is also shown.

TABLE 6.—*Total costs per 1,000 board feet of logging and hauling ties, with and without interest charges, based on various teaming costs and daily hauling capacities.*

| Daily hauling capacity for one team. | Teaming wage rate per day. | Total cost per 1,000 board feet. | | | Total cost per thousand board feet (including 6 per cent interest). |
|---|---|---|---|---|---|
| | | Minimum. | Maximum. | Average. | |
| 1,000 board feet | $5.50 | $9.60 | $13.50 | $11.10 | $11.77 |
| | 5.00 | 9.10 | 13.00 | 10.60 | 11.24 |
| | 4.50 | 8.60 | 12.50 | 10.10 | 10.71 |
| | 4.00 | 8.10 | 12.00 | 9.60 | 10.18 |
| 2,000 board feet | 5.50 | 6.85 | 10.75 | 8.35 | 8.85 |
| | 5.00 | 6.60 | 10.50 | 8.10 | 8.59 |
| | 4.50 | 6.35 | 10.25 | 7.85 | 8.32 |
| | 4.00 | 6.10 | 10.00 | 7.60 | 8.06 |
| 3,000 board feet | 5.50 | 5.93 | 9.83 | 7.43 | 7.88 |
| | 5.00 | 5.77 | 9.67 | 7.27 | 7.71 |
| | 4.50 | 5.50 | 9.50 | 7.10 | 7.53 |
| | 4.00 | 5.43 | 9.33 | 6.93 | 7.35 |

## POLES.

Pole logging is much the simplest and cheapest form of exploitation per unit of volume. It consists simply of felling the tree, sawing off the top at an inside bark diameter of 7 inches, trimming the branches close, and peeling. The cost of this is usually figured at 1 cent per foot in length for poles from 25 to 35 feet long and 35 cents apiece for poles from 35 to 50 feet long. Pole cutting is more expensive in winter, when peeling is most difficult. Contract logging rates are often 35 cents per pole in winter and 25 cents in summer. Some companies, however, accept only winter-cut poles,

since the warm temperature and the greater amount of moisture in the outer layers of sapwood during summer favor attacks by wood-rotting fungi.

Table 7 gives the approximate cost per pole of hauling and, in addition, the total cost per pole of cutting and delivering various sizes, including interest at 6 per cent for one year on the money invested, based upon the figures given in Table 2 for wage rates and number of daily trips possible, and those on page 22 for wagonloads of different sized poles.

TABLE 7.—*Cost per pole of hauling, and total cost of cutting*[1] *and hauling combined with interest at 6 per cent for one year on money invested, for poles of various lengths and for different teaming rates and daily hauling capacities.*

| Daily hauling capacity for 1 team. | Teaming wage rate per day. | 25–30 foot (6 poles per load). | | 35-foot (4 poles per load). | | 40–45 foot (2 poles per load). | | 50-foot (1 pole per load). | |
|---|---|---|---|---|---|---|---|---|---|
| | | Cost of hauling. | Total cost, including interest. | Cost of hauling. | Total cost, including interest. | Cost of hauling. | Total cost, including interest. | Cost of hauling. | Total cost, including interest. |
| 1 trip..... | $5.50 | $0.92 | $1.29 | $1.38 | $1.78 | $2.75 | $3.29 | $5.50 | $6.20 |
| | 5.00 | .83 | 1.20 | 1.25 | 1.64 | 2.50 | 3.02 | 5.00 | 5.67 |
| | 4.50 | .75 | 1.11 | 1.13 | 1.51 | 2.25 | 2.76 | 4.50 | 5.14 |
| | 4.00 | .67 | 1.03 | 1.00 | 1.38 | 2.00 | 2.49 | 4.00 | 4.61 |
| 2 trips..... | 5.50 | .46 | .80 | .69 | 1.05 | 1.38 | 1.83 | 2.75 | 3.29 |
| | 5.00 | .42 | .76 | .63 | .98 | 1.25 | 1.70 | 2.50 | 3.02 |
| | 4.50 | .38 | .72 | .56 | .91 | 1.13 | 1.56 | 2.25 | 2.76 |
| | 4.00 | .33 | .67 | .50 | .85 | 1.00 | 1.43 | 2.00 | 2.49 |
| 3 trips..... | 5.50 | .31 | .64 | .46 | .80 | .92 | 1.34 | 1.83 | 2.31 |
| | 5.00 | .28 | .61 | .42 | .76 | .83 | 1.26 | 1.67 | 2.14 |
| | 4.50 | .25 | .58 | .38 | .72 | .75 | 1.17 | 1.50 | 1.96 |
| | 4.00 | .22 | .55 | .33 | .67 | .67 | 1.08 | 1.33 | 1.78 |

[1] Cost of cutting and hauling assumed to be: 30 cents for poles 25–35 feet long; 35 cents for poles over 35 feet long.

## CORDWOOD.

The cost of cordwood cutting varies from about 90 cents to $1.25 per stacked cord of 4-foot wood. When oak and other tough-wooded species predominate, the cost is usually higher than when chestnut is the principal tree. One dollar per cord may be considered a fair average for the State.

An ordinary wagonload varies from 1 to 1½ cords. By adding the cost of cutting (assumed to be $1 per cord) to that given in Table 2 for hauling at different wage rates and distances, and including interest charges for one year at 6 per cent on the money invested in the operation, the approximate total costs given in Table 8 are obtained.

TABLE 8.—*Approximate total cost per cord*[1] *of cutting and delivering for various wage rates and hauling capacities, including interest charges at 6 per cent for one year.*

| Daily hauling capacity for 1 team. | Teaming wage rate per day. | Total cost, with interest, per cord. | Daily hauling capacity for 1 team. | Teaming wage rate per day. | Total cost, with interest, per cord. |
|---|---|---|---|---|---|
| 1 cord | $5.50 | $6.89 | 4 cords | $5.50 | $2.52 |
| | 5.00 | 6.36 | | 5.00 | 2.39 |
| | 4.50 | 5.83 | | 4.50 | 2.26 |
| | 4.00 | 5.30 | | 4.00 | 2.12 |
| 2 cords | 5.50 | 3.98 | 5 cords | 5.50 | 2.23 |
| | 5.00 | 3.71 | | 5.00 | 2.12 |
| | 4.50 | 3.45 | | 4.50 | 2.01 |
| | 4.00 | 3.18 | | 4.00 | 1.91 |
| 3 cords | 5.50 | 3.00 | | | |
| | 5.00 | 2.83 | | | |
| | 4.50 | 2.65 | | | |
| | 4.00 | 2.47 | | | |

[1] Cost of cutting alone assumed to be $1 per cord.

## VALUE OF STANDING TIMBER.

### BASIS OF VALUE.

The stumpage values for lumber, ties, poles, and cordwood given in this chapter are derived from the market values and the average costs of operation given in the two preceding chapters.

The real stumpage value is the difference between the market value and the total operating costs, less a reasonable profit on the combined investment in stumpage and logging. This may be expressed as an equation: $S=\frac{M}{1\ .0p}-C$, in which S represents stumpage value; M, market value; C, cost of logging; and p, rate of profit. For any desired per cent of profit on the stumpage and logging investment the formula would read as follows:

For a profit of
- 10 per cent: $S=\frac{10}{11}M-C$
- 15 per cent: $S=\frac{20}{23}M-C$
- 20 per cent: $S=\frac{5}{6}M-C$
- 25 per cent: $S=\frac{4}{5}M-C$
- 30 per cent: $S=\frac{10}{13}M-C$

To determine the amount of profit, add the stumpage value thus found to the logging costs and subtract the sum from the market value.

In constructing the stumpage tables it was necessary to assume a definite per cent of profit, in this case 20. When stumpage values for investments at other rates are desired, they should be derived by means of the formula.

The stumpage values given are applicable only to cases in which the costs of production are the same as those given in the tables. Where the costs differ from the average given the stumpage value can be derived by substituting the actual logging costs for those in the tables. The figures in the tables, however, represent with fair accuracy the

present value of standing timber in Connecticut at different distances from market. They also serve to illustrate a method by which a forest owner may obtain a substantially correct valuation of his standing timber.

The chief factor affecting the value of timber, aside from its character and quality, is the distance to market. The character of the topography and the condition of the roads must, of course, be taken into account, since these influence the cost of hauling and therefore the stumpage value. In Tables 9 to 16 the stumpage values are classified according to the daily hauling capacity of a single team and wagon for a specified material. The column headed "Total logging cost per thousand" includes the hauling (varied) costs and the average combined (constant) costs of all other parts of the operation.

Tables 9, 11, 13, and 15 give the combined stumpage and profit, and Tables 10, 12, 14, and 16 the stumpage value alone, reckoned for an assumed profit of 20 per cent on the total investment in timber and logging operations combined. The amount remaining as stumpage value after deducting the profit includes also interest and taxes on the woodland which have accrued up to the present time. Interest for one year on the cost of operation has already been included (see Tables 4, 6, 7, and 8), and it may be disregarded in the stumpage calculation.

### LUMBER.

Tables 9 and 10, which give stumpage values for lumber, are based on the total costs, including interest, given in Table 4, which in turn are based on the average cost, $7.75 per thousand feet for logging and sawing, given in Table 3. They are also derived from market values of from $18 to $35. The combined stumpage and profit is the difference between these two amounts. The stumpage value is this difference minus an assumed profit of 20 per cent on the total investment. The figures for stumpage value, with and without an included profit, are given for each market value of lumber and for each logging cost, as determined by the different wage rates and different wagonload capacities per day. The last can easily be converted to distances from market for any specified case. With good roads of easy grade, and with loads of 1,000 board feet, a round-trip haul of 1,000 board feet per day ought to correspond to a distance of 9 miles from market; two round trips, hauling 2,000 board feet, to a distance of 4½ miles; and three round trips, with 3,000 board feet, to 3 miles.

Under the conditions presented in Table 9 the purchaser who had to pay for stumpage the amount per thousand feet specified could not market his timber for more than enough to pay the costs of stumpage and lumbering. The reader should avoid confusing this with the true stumpage value shown for a profit of 20 per cent in Table 10.

TABLE 9.—*Combined stumpage value and profit for lumber, for various hauling costs and market values.*

| Daily hauling capacity for 1 team. | Teaming cost per day. | Total logging cost per M.[1] | Stumpage + profit per thousand board feet for market values of— | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | $18 per M. | $20 per M. | $22 per M. | $24 per M. | $25 per M. | $30 per M. | $35 per M. |
| 1,000 board feet | $5.50 | $14.05 | $3.95 | $5.95 | $7.95 | $9.95 | $10.95 | $15.95 | $20.95 |
| | 5.00 | 13.52 | 4.48 | 6.48 | 8.48 | 10.48 | 11.48 | 16.48 | 21.48 |
| | 4.50 | 12.98 | 5.02 | 7.02 | 9.02 | 11.02 | 12.02 | 17.02 | 22.02 |
| | 4.00 | 12.46 | 5.54 | 7.54 | 9.54 | 11.54 | 12.54 | 17.54 | 22.54 |
| 2,000 board feet | 5.50 | 11.13 | 6.87 | 8.87 | 10.87 | 12.87 | 13.87 | 18.87 | 23.87 |
| | 5.00 | 10.87 | 7.13 | 9.13 | 11.13 | 13.13 | 14.13 | 19.13 | 24.13 |
| | 4.50 | 10.60 | 7.40 | 9.40 | 11.40 | 13.40 | 14.40 | 19.40 | 24.40 |
| | 4.00 | 10.34 | 7.66 | 9.66 | 11.66 | 13.66 | 14.66 | 19.66 | 24.66 |
| 3,000 board feet | 5.50 | 10.15 | 7.85 | 9.85 | 11.85 | 13.85 | 14.85 | 19.85 | 24.85 |
| | 5.00 | 9.98 | 8.02 | 10.02 | 12.02 | 14.02 | 15.02 | 20.02 | 25.02 |
| | 4.50 | 9.81 | 8.19 | 10.19 | 12.19 | 14.19 | 15.19 | 20.19 | 25.19 |
| | 4.00 | 9.63 | 8.37 | 10.37 | 12.37 | 14.37 | 15.37 | 20.37 | 25.37 |

[1] The total logging costs are those given in Table 4, and include interest at 6 per cent for one year on the money invested in the logging operation.

TABLE 10.—*Stumpage value of lumber after deducting a profit of 20 per cent for different hauling costs and market values.*

| Daily hauling capacity for 1 team. | Teaming cost per day. | Total logging cost per M.[1] | Stumpage value per thousand board feet for market values of— | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | $18 profit= $3 per M. | $20 profit= $3.33 per M. | $22 profit= $3.67 per M. | $24 profit= $4 per M. | $25 profit= $4.17 per M. | $30 profit= $5 per M. |
| 1,000 board feet | $5.50 | $14.05 | $0.95 | $2.62 | $4.20 | $5.95 | $6.78 | $10.95 |
| | 5.00 | 13.52 | 1.48 | 3.15 | 4.81 | 6.48 | 7.32 | 11.48 |
| | 4.50 | 12.98 | 2.02 | 3.69 | 5.35 | 7.02 | 7.85 | 12.02 |
| | 4.00 | 12.46 | 2.54 | 4.21 | 5.77 | 7.54 | 8.37 | 12.54 |
| 2,000 board feet | 5.50 | 11.13 | 3.87 | 5.54 | 7.20 | 8.87 | 9.70 | 13.87 |
| | 5.00 | 10.87 | 4.13 | 5.80 | 7.46 | 9.13 | 9.96 | 14.13 |
| | 4.50 | 10.60 | 4.40 | 6.07 | 7.73 | 9.40 | 10.23 | 14.40 |
| | 4.00 | 10.34 | 4.66 | 6.33 | 7.99 | 9.66 | 10.49 | 14.66 |
| 3,000 board feet | 5.50 | 10.15 | 4.85 | 6.52 | 8.18 | 9.85 | 10.68 | 14.85 |
| | 5.00 | 9.98 | 5.02 | 6.69 | 8.35 | 10.02 | 10.85 | 15.02 |
| | 4.50 | 9.81 | 5.19 | 6.86 | 8.52 | 10.19 | 11.02 | 15.19 |
| | 4.00 | 9.63 | 5.37 | 7.04 | 8.70 | 10.37 | 11.20 | 15.37 |

[1] The total logging costs are those given in Table 4, and include interest at 6 per cent for one year on the money invested in the logging operation.

## TIES.

In Tables 11 and 12, which give stumpage values for ties with and without a profit of 20 per cent, the total costs given in Table 6 were assumed as average for all sizes of ties. The market values are for 1,000 board feet; for 7 by 9 inch ties, running 25 to the thousand, at 72 cents apiece, or $18 per thousand feet; for first-class ties, running 32 to the thousand, at 50 cents apiece, or $16; and for second-class ties, running 38 to the thousand, at 30 cents apiece, or $11.40.

Stumpage values for different distances from the point of delivery can be read from the stumpage table by converting the daily hauling capacity into miles, as described for lumber on page 25.

TABLE 11.—*Combined stumpage values and profits for ties, for different hauling costs and market values.*

| Daily hauling capacity for 1 team. | Teaming cost per day. | Total logging cost per M.[1] | Stumpage+profit, per thousand and per tie, for— | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | Second-class ties at $11.40 per M, or 30 cents per tie. | | First-class ties at $16 per M, or 50 cents per tie. | | 7 by 9 inch ties at $18 per M, or 72 cents per tie. | |
| | | | *Per M.* | *Per tie.* | *Per M.* | *Per tie.* | *Per M.* | *Per tie.* |
| 1,000 board feet | $5.50 | $11.77 | ..... | ..... | $4.23 | $0.132 | $6.25 | $0.249 |
| | 5.00 | 11.24 | $0.16 | $0.004 | 4.76 | .148 | 6.76 | .270 |
| | 4.50 | 10.71 | .69 | .018 | 5.29 | .165 | 7.29 | .292 |
| | 4.00 | 10.18 | 1.22 | .032 | 5.82 | .181 | 7.82 | .313 |
| 2,000 board feet | 5.50 | 8.85 | 2.55 | .067 | 7.15 | .223 | 9.15 | .366 |
| | 5.00 | 8.59 | 2.81 | .079 | 7.41 | .231 | 9.41 | .376 |
| | 4.50 | 8.32 | 3.08 | .081 | 7.68 | .240 | 9.68 | .387 |
| | 4.00 | 8.06 | 3.34 | .088 | 7.94 | .248 | 9.94 | .398 |
| 3,000 board feet | 5.50 | 7.88 | 3.52 | .093 | 8.12 | .254 | 10.12 | .405 |
| | 5.00 | 7.71 | 3.69 | .097 | 8.29 | .259 | 10.29 | .412 |
| | 4.50 | 7.53 | 3.87 | .102 | 8.47 | .264 | 10.47 | .419 |
| | 4.00 | 7.35 | 4.05 | .107 | 8.65 | .270 | 10.65 | .426 |

[1] The total logging costs are those given in Table 6, and include interest at 6 per cent for one year on the money invested in the logging operation.

TABLE 12.—*Stumpage values of ties, after deducting a profit of 20 per cent for different hauling costs and market values.*

| Daily hauling capacity for 1 team. | Teaming cost per day. | Total logging cost per M.[1] | Stumpage value per 1,000 board feet and per tie for market values of— | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | $11.40 per M or 30 cents per tie; profit = $1.90 per M, or 5 cents per tie. | | $16 per M or 50 cents per tie; profit = $2.67 per M, or 8.3 cents per tie. | | $18 per M or 72 cents per tie; profit = $3 per M, or 12 cents per tie. | |
| | | | *Per M.* | *Per tie.* | *Per M.* | *Per tie.* | *Per M.* | *Per tie.* |
| 1,000 board feet | $5.50 | $11.77 | ..... | ..... | $1.57 | $0.049 | $3.23 | $0.129 |
| | 5.00 | 11.24 | ..... | ..... | 2.09 | .065 | 3.76 | .150 |
| | 4.50 | 10.71 | ..... | ..... | 2.62 | .082 | 4.29 | .172 |
| | 4.00 | 10.18 | ..... | ..... | 3.15 | .098 | 4.82 | .193 |
| 2,000 board feet | 5.50 | 8.85 | $0.65 | $0.017 | 4.48 | .140 | 6.15 | .246 |
| | 5.00 | 8.59 | .92 | .024 | 4.74 | .148 | 6.41 | .256 |
| | 4.50 | 8.32 | 1.18 | .031 | 5.01 | .157 | 6.68 | .267 |
| | 4.00 | 8.06 | 1.44 | .038 | 5.27 | .165 | 6.94 | .278 |
| 3,000 board feet | 5.50 | 7.88 | 1.62 | .043 | 5.45 | .171 | 7.12 | .285 |
| | 5.00 | 7.71 | 1.79 | .047 | 5.62 | .176 | 7.29 | .292 |
| | 4.50 | 7.53 | 1.97 | .052 | 5.80 | .181 | 7.47 | .299 |
| | 4.00 | 7.35 | 2.15 | .057 | 5.98 | .187 | 7.65 | .306 |

[1] The total logging costs are those given in Table 6, and include interest at 6 per cent for one year on the money invested in the logging operation.

## POLES.

Tables 13 and 14, which give stumpage values for poles, are based on the total logging cost given in Table 7.

TABLE 13.—*Combined stumpage values* [1] *and profits for poles of different lengths, for different hauling costs and market values.*

| Daily hauling capacity for 1 team. | Teaming cost per day. | Stumpage + profit, per pole, for— | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | 25-foot poles at $1.90. | 30-foot poles at $3. | 35-foot poles at $4.10. | 40-foot poles at $5.30. | 45-foot poles at $6.90. | 50-foot poles at $9. | 55-foot poles at $12.10. | 60-foot poles at $15. |
| 1 trip..... | $5.50 | $0.61 | $1.71 | $2.32 | $2.01 | $3.61 | $2.80 | $5.90 | $8.80 |
| | 5.00 | .70 | 1.80 | 2.46 | 2.28 | 3.88 | 3.33 | 6.43 | 9.33 |
| | 4.50 | .79 | 1.89 | 2.59 | 2.54 | 4.14 | 3.86 | 6.96 | 9.86 |
| | 4.00 | .87 | 1.97 | 2.72 | 2.81 | 4.41 | 4.39 | 7.49 | 10.39 |
| 2 trips..... | 5.50 | 1.10 | 2.20 | 3.05 | 3.47 | 5.07 | 5.71 | 8.81 | 11.71 |
| | 5.00 | 1.14 | 2.24 | 3.12 | 3.60 | 5.20 | 5.98 | 9.08 | 11.98 |
| | 4.50 | 1.18 | 2.28 | 3.19 | 3.74 | 5.34 | 6.24 | 9.34 | 12.24 |
| | 4.00 | 1.23 | 2.33 | 3.25 | 3.87 | 5.47 | 6.51 | 9.61 | 12.51 |
| 3 trips..... | 5.50 | 1.26 | 2.36 | 3.30 | 3.96 | 5.56 | 6.69 | 9.79 | 12.69 |
| | 5.00 | 1.29 | 2.39 | 3.34 | 4.04 | 5.64 | 6.86 | 9.96 | 12.86 |
| | 4.50 | 1.32 | 2.42 | 3.38 | 4.13 | 5.73 | 7.04 | 10.14 | 13.04 |
| | 4.00 | 1.35 | 2.45 | 3.43 | 4.22 | 5.82 | 7.22 | 10.32 | 13.22 |

[1] Based on approximate total costs of cutting and delivering poles of various lengths, with interest at 6 per cent for one year, given in Table 7.

TABLE 14.—*Stumpage values* [1] *for poles of different lengths, after deducting a profit of 20 per cent for different hauling costs and market values.*

| Daily hauling capacity for 1 team. | Teaming cost per day. | Stumpage value per pole for— | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | 25-foot poles at $1.90; profit = $0.316 per pole. | 30-foot poles at $3; profit = $0.50 per pole. | 35-foot poles at $4.10; profit = $0.684 per pole. | 40-foot poles at $5.30; profit = $0.884 per pole. | 45-foot poles at $6.90; profit = $1.15 per pole. | 50-foot poles at $9; profit = $1.50 per pole. | 55-foot poles at $12.10; profit = $2.02 per pole. | 60-foot poles at $15; profit = $2.50 per pole. |
| 1 trip..... | $5.50 | $0.29 | $1.21 | $1.64 | $1.13 | $2.46 | $1.30 | $3.88 | $6.30 |
| | 5.00 | .38 | 1.30 | 1.78 | 1.40 | 2.73 | 1.83 | 4.41 | 6.83 |
| | 4.50 | .47 | 1.39 | 1.91 | 1.66 | 2.99 | 2.36 | 4.94 | 7.36 |
| | 4.00 | .55 | 1.47 | 2.04 | 1.93 | 3.26 | 2.89 | 5.47 | 7.98 |
| 2 trips..... | 5.50 | .78 | 1.70 | 2.37 | 2.59 | 3.92 | 4.21 | 6.79 | 9.21 |
| | 5.00 | .82 | 1.74 | 2.44 | 2.72 | 4.05 | 4.48 | 7.06 | 9.48 |
| | 4.50 | .86 | 1.78 | 2.51 | 2.86 | 4.19 | 4.74 | 7.32 | 9.74 |
| | 4.00 | .91 | 1.83 | 2.57 | 2.99 | 4.32 | 5.01 | 7.59 | 10.01 |
| 3 trips..... | 5.50 | .94 | 1.86 | 2.62 | 3.08 | 4.41 | 5.19 | 7.77 | 10.19 |
| | 5.00 | .97 | 1.89 | 2.66 | 3.16 | 4.49 | 5.36 | 7.94 | 10.36 |
| | 4.50 | 1.00 | 1.92 | 2.70 | 3.25 | 4.58 | 5.54 | 8.12 | 10.54 |
| | 4.00 | 1.03 | 1.95 | 2.75 | 3.34 | 4.67 | 5.72 | 8.30 | 10.72 |

[1] Based on approximate total costs of cutting and delivering poles of various lengths, with interest at 6 per cent for one year, given in Table 7.

## CORDWOOD.

Tables 15 and 16 are based on the approximate total cost per cord of cutting and delivering cordwood, with interest at 6 per cent for one year, shown in Table 8.

TABLE 15.—*Combined stumpage values and profits for cordwood for different hauling costs and market values.*

| Daily hauling capacity for 1 team. | Teaming cost per day. | Total cost per cord.[1] | Stumpage + profit per cord for market values per cord of— | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | $3.00 | $3.50 | $4.00 | $4.50 | $5.00 | $5.50 | $6.00 | $6.50 | $7.00 |
| 1 cord | $5.50 | $6.89 | | | | | | | | | $0.11 |
| | 5.00 | 6.36 | | | | | | | | $0.14 | .64 |
| | 4.50 | 5.83 | | | | | | | $0.17 | .67 | 1.17 |
| | 4.00 | 5.30 | | | | | | $0.20 | .70 | 1.20 | 1.70 |
| 2 cords | 5.50 | 3.98 | | | $0.02 | $0.52 | $1.02 | 1.52 | 2.02 | 2.52 | 3.02 |
| | 5.00 | 3.71 | | | .29 | .79 | 1.29 | 1.79 | 2.29 | 2.79 | 3.29 |
| | 4.50 | 3.45 | | $0.05 | .55 | 1.05 | 1.55 | 2.05 | 2.55 | 3.05 | 3.55 |
| | 4.00 | 3.18 | | .32 | .82 | 1.32 | 1.82 | 2.32 | 2.82 | 3.32 | 3.82 |
| 3 cords | 5.50 | 3.00 | | .50 | 1.00 | 1.50 | 2.00 | 2.50 | 3.00 | 3.50 | 4.00 |
| | 5.00 | 2.83 | $0.17 | .67 | 1.17 | 1.67 | 2.17 | 2.67 | 3.17 | 3.67 | 4.17 |
| | 4.50 | 2.65 | .35 | .85 | 1.35 | 1.85 | 2.35 | 2.85 | 3.35 | 3.85 | 4.35 |
| | 4.00 | 2.47 | .53 | 1.03 | 1.53 | 2.03 | 2.53 | 3.03 | 3.53 | 4.03 | 4.53 |
| 4 cords | 5.50 | 2.52 | .48 | .98 | 1.48 | 1.98 | 2.48 | 2.98 | 3.48 | 3.98 | 4.48 |
| | 5.00 | 2.39 | .61 | 1.11 | 1.61 | 2.11 | 2.61 | 3.11 | 3.61 | 4.11 | 4.61 |
| | 4.50 | 2.26 | .74 | 1.24 | 1.74 | 2.24 | 2.74 | 3.24 | 3.74 | 4.24 | 4.74 |
| | 4.00 | 2.12 | .88 | 1.38 | 1.88 | 2.38 | 2.88 | 3.38 | 3.88 | 4.38 | 4.88 |
| 5 cords | 5.50 | 2.23 | .77 | 1.27 | 1.77 | 2.27 | 2.77 | 3.27 | 3.77 | 4.27 | 4.77 |
| | 5.00 | 2.12 | .88 | 1.38 | 1.88 | 2.38 | 2.88 | 3.38 | 3.88 | 4.38 | 4.88 |
| | 4.50 | 2.01 | .99 | 1.49 | 1.99 | 2.49 | 2.99 | 3.49 | 3.99 | 4.49 | 4.99 |
| | 4.00 | 1.91 | 1.09 | 1.59 | 2.09 | 2.59 | 3.09 | 3.59 | 4.09 | 4.59 | 5.09 |

[1] The total costs per cord are those given in Table 11, and include interest at 6 per cent for one year on the money invested in the operation.

TABLE 16.—*Stumpage values for cordwood, after deducting a profit of 20 per cent for different hauling costs and market values.*

| Daily hauling capacity for 1 team. | Teaming cost per day. | Total cost per cord.[1] | Stumpage value per cord for market values per cord of— | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | $3; profit = $0.50 | $3.50; profit = $0.58 | $4; profit = $0.67 | $4.50; profit = $0.75 | $5; profit = $0.83 | $5.50; profit = $0.92 | $6; profit = $1 | $6.50; profit = $1.08 | $7; profit = $1.17 |
| 1 cord | $5.50 | $6.89 | | | | | | | | | |
| | 5.00 | 6.36 | | | | | | | | | |
| | 4.50 | 5.83 | | | | | | | | | |
| | 4.00 | 5.30 | | | | | | | | $0.12 | $0.53 |
| 2 cords | 5.50 | 3.98 | | | | | $0.18 | $0.60 | $1.02 | 1.44 | 1.85 |
| | 5.00 | 3.71 | | | | $0.04 | .46 | .87 | 1.29 | 1.71 | 2.12 |
| | 4.50 | 3.45 | | | | .30 | .72 | 1.13 | 1.55 | 1.97 | 2.38 |
| | 4.00 | 3.18 | | | $0.15 | .57 | .99 | 1.90 | 1.82 | 2.24 | 2.65 |
| 3 cords | 5.50 | 3.00 | | | .33 | .75 | 1.17 | 1.58 | 2.00 | 2.42 | 2.83 |
| | 5.00 | 2.83 | | $0.09 | .50 | .92 | 1.34 | 1.75 | 2.17 | 2.59 | 3.00 |
| | 4.50 | 2.65 | | .27 | .68 | 1.10 | 1.52 | 1.93 | 2.35 | 2.77 | 3.18 |
| | 4.00 | 2.47 | | .45 | .86 | 1.28 | 1.70 | 2.11 | 2.53 | 2.95 | 3.36 |
| 4 cords | 5.50 | 2.52 | | .40 | .81 | 1.23 | 1.65 | 2.06 | 2.48 | 2.90 | 3.31 |
| | 5.00 | 2.39 | $0.11 | .53 | .94 | 1.36 | 1.78 | 2.19 | 2.61 | 3.03 | 3.44 |
| | 4.50 | 2.26 | .24 | .66 | 1.07 | 1.49 | 1.91 | 2.32 | 2.74 | 3.16 | 3.57 |
| | 4.00 | 2.12 | .38 | .80 | 1.21 | 1.63 | 2.05 | 2.46 | 2.88 | 3.30 | 3.71 |
| 5 cords | 5.50 | 2.23 | .27 | .69 | 1.10 | 1.52 | 1.94 | 2.35 | 2.77 | 3.19 | 3.60 |
| | 5.00 | 2.12 | .38 | .80 | 1.21 | 1.63 | 2.05 | 2.46 | 2.88 | 3.30 | 3.71 |
| | 4.50 | 2.01 | .49 | .91 | 1.32 | 1.74 | 2.16 | 2.57 | 2.99 | 3.41 | 3.82 |
| | 4.00 | 1.91 | .59 | 1.01 | 1.42 | 1.84 | 2.26 | 2.67 | 3.09 | 3.51 | 3.92 |

[1] The total costs per cord are those given in Table 8, and include interest at 6 per cent on the money invested in the operation.

## PART III.—YIELD OF EVEN-AGED HARDWOOD STANDS.

### FACTORS WHICH INFLUENCE THE YIELD.

If second-growth hardwood stands are to be handled for steady and increasing returns, it is essential to know the probable yield; that is, the amount and character of products obtainable within a given period. It is a common saying among Connecticut farmers that a woodlot will produce on the average about a cord per acre per year. As a matter of fact, the rate at which stands grow is quite variable, and is influenced by a number of different factors. Three especially have an important influence upon the yield. These are, first, the type of forest; second, the productive quality of the locality; and third, the number and size of the trees on the area, or the "growing stock."

#### TYPES.

Even-aged hardwood stands on the Connecticut uplands, as already described, consist chiefly of chestnut and a few species of oak. Occasionally, over small areas, both oak[1] and chestnut form pure or nearly pure stands, but for the most part the forest is a mixture of two or more species in every degree of gradation between pure chestnut and pure oak. Since the yield and value and, to a large extent, the management of these stands depend directly upon their composition, it is necessary to classify them upon this basis into the three general types: The chestnut type, containing 60 per cent or more, by volume, of chestnut; the oak type, containing 60 per cent or more of oak; and the oak-chestnut type, containing 60 per cent or more of mixed oak and chestnut, but less than 60 per cent of either alone. Of these, the oak type might be further divided into chestnut-oak and black oak subtypes, but since these are not very dissimilar in yield and comprise a relatively small portion of the woodland of the State, they can be ignored.

Differences in type result chiefly, though not solely, from differences in soil conditions. Of these, the depth, degree of slope, drainage, and moisture-retaining capacity are most important. The three types require good drainage, but chestnut requires for its best growth considerably more moisture than black, scarlet, or chestnut oak, and consequently gives place to these species on dry upper slopes with shallow soil. On deep, well-drained, sandy loams chestnut tends to exclude the slower-growing oaks. The chestnut type is therefore most abundant on the lower portions of slopes, benches, and on well-drained, level lands, with deep, fresh soil, while the oak type is more characteristic of dry upper slopes and ridge tops. The oak-chestnut type here considered occupies situations intermediate as

[1] Stands composed of more than one species of oak are here considered pure oak stands.

regards soil moisture between those occupied by the two other types. There is, however, another oak-chestnut type which is often found on moist, well-drained, lowland soil, where red oak thrives and nearly equals chestnut in its rate of growth. This is similar in yield to the chestnut type.

### QUALITY CLASSES.

Soil conditions are largely responsible not only for differences in type but also for variations in the rate of growth within the same type. The yield to be expected from a stand within a given period thus depends directly upon the quality of the site. For this reason three different qualities of situation, or quality classes, have been distinguished. The best index to the quality of a situation is the rate of growth in height of the trees which occupy it. Thus the best soils show the best height growth, and the poorest sites the poorest growth, provided all other conditions are equal. The basis for the difference in the quality classes is therefore the average height at a given age of the tallest or dominant trees of the principal species in an even-aged stand. In quality I, therefore, the dominant trees exceed a certain minimum height, which varies, of course, with age. In quality II they fall below this, but above the maximum for quality III. The classification is shown graphically in figure 1, in which the quality class separation is indicated with dotted curves. In the yield tables which follow, the average heights of dominant trees at 5-year intervals are given for each quality class.

Quality classes are determined for each type separately, without regard to corresponding qualities in other types. Since chestnut almost invariably occupies the better soils, it is evident that first-quality oak, not being the same in yield, can not be compared with first-quality chestnut; nor third-quality oak with third-quality chestnut.

### GROWING STOCK.

In any type the number of trees per acre at a given age varies widely. When the whole area is occupied by thrifty, long-stemmed trees, each with a sufficient space in which to grow rapidly, the ground may be said to be "normally stocked." Too many trees cause crowding, which results in slender, weak, slow-growing stands; too few do not fully utilize the soil and growing space, and produce limby stands of relatively low value.

Understocked stands result from scanty or irregular reproduction, or from fire, grazing, disease, or too heavy thinning. The chestnut blight is already a cause of understocking in the southwestern part of the State. In this study only average fully stocked stands were selected for measurement. No plots were measured in which the crowns of the trees did not occupy approximately the total amount

of the available growing space. Later these plots were checked on the total basal area per acre. By this is meant the sum of the cross-section areas at breastheight of all the trees in a measured sample of the stand, usually expressed in square feet. It varies with the number of trees, their average diameter, and consequently the age of the stand, and is one of the best means of judging whether a stand of known age is fully stocked or not. The average total basal area per

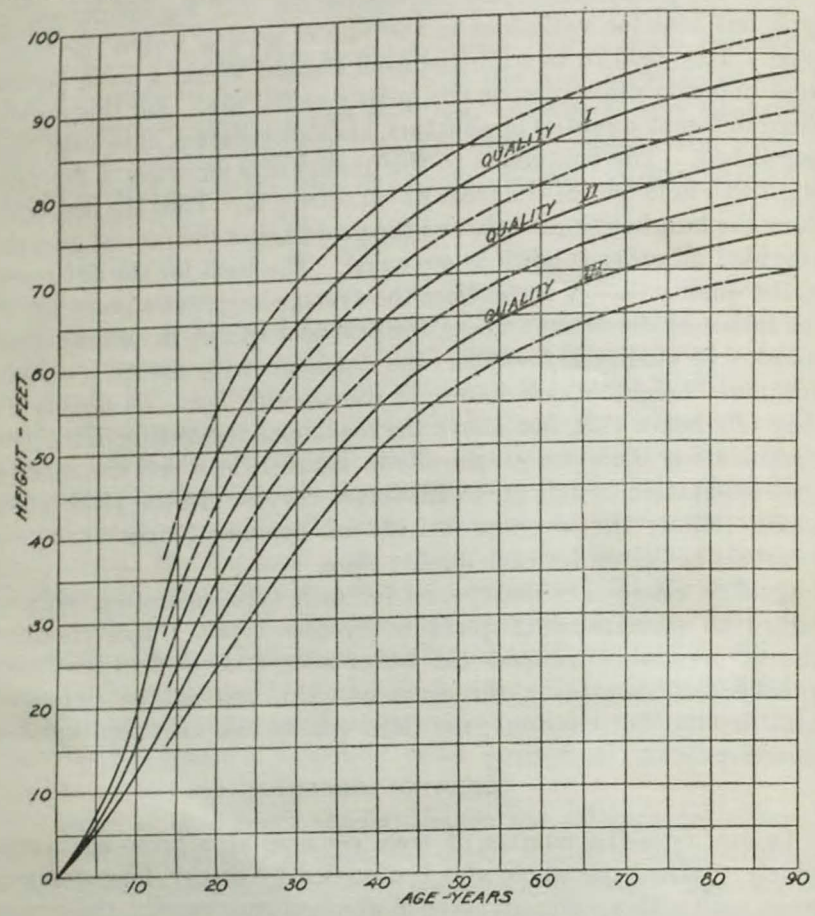


FIG. 1.—Height growth of dominant trees, chestnut type.

acre of all the measured plots was then determined, and all plots the total basal area of which was greater or less than the average by 10 per cent or more were assumed to be abnormally stocked and were eliminated from further computation. The yield tables are, therefore, based on average fully stocked stands. The method of elimination is illustrated graphically in figure 2.

In the yield tables themselves the average basal area by five-year periods is shown for each type and for each quality class. The

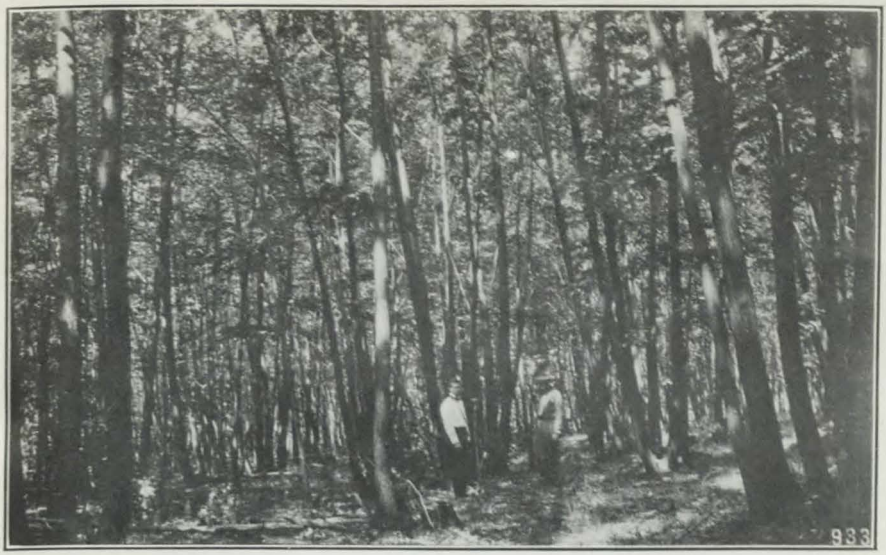

FIG. 1.—THIRTY-SEVEN-YEAR-OLD STAND OF QUALITY II CHESTNUT.

Yield per acre either 2,500 board feet of lumber and 29 cords of wood, or 60 Class I ties with 30 cords. Cordwood yield alone about 37 cords.

FIG. 2.—FIFTY-YEAR-OLD STAND OF QUALITY I CHESTNUT.

Yield per acre about 13,800 board feet of lumber and 28 cords, or 430 ties and 35 cords, or 40 25-35 foot poles with 185 ties and 40 cords. Cordwood yield alone about 57 cords.

figures given are approximately accurate for stands whose basal area does not vary from the average for a given age by more than 10 per cent, but must be modified if applied to stands outside of this range.

The number of trees per acre varies greatly even in fully stocked stands of the same age. The number, of course, diminishes as the trees grow larger. This decrease is very rapid during youth, when

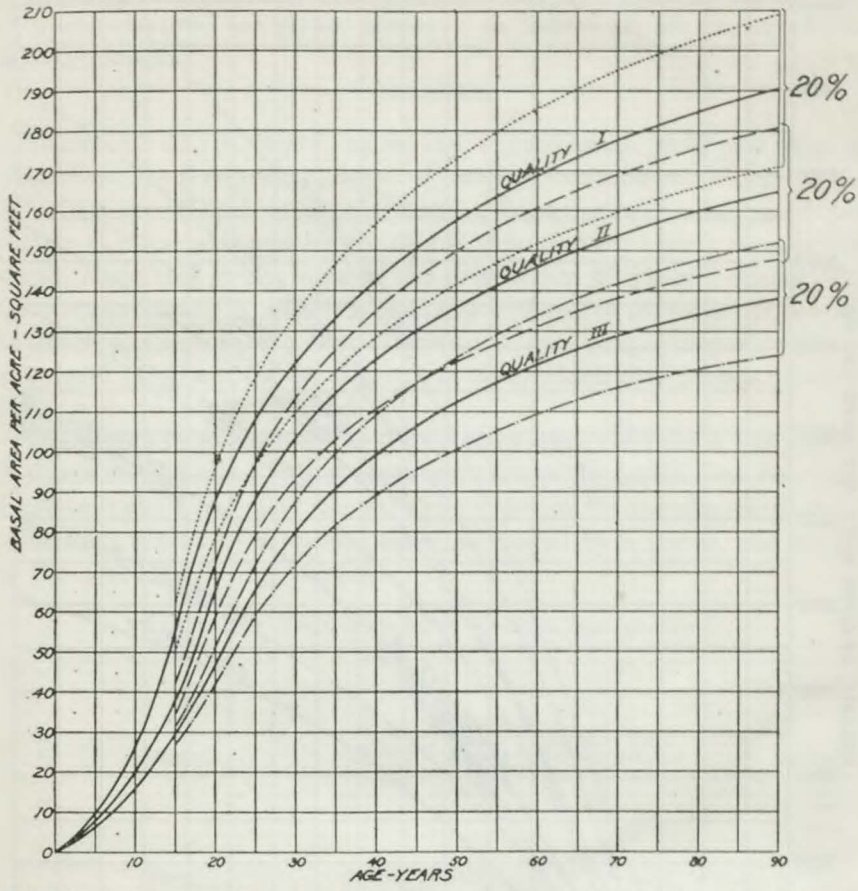


FIG. 2.—Basal area per acre, in square feet, for three quality classes, chestnut type. The heavy lines represent the average for each quality. The pairs of broken lines, united by braces, include a range of 20 per cent from the average, within which plots were considered to be normally stocked.

competition is keen, but gradually lessens as the surviving trees approach maturity. Since growth is more rapid and competition more keen in good sites than in poor ones, the number of trees is less and their size greater in quality I than in quality III stands of the same age and type. The average number of trees per acre and the corresponding average diameters at different ages are shown in the yield tables.

## YIELD TABLES.

The following tables, which give approximate yields per acre for unmanaged even-aged hardwood stands are based on 187 plots

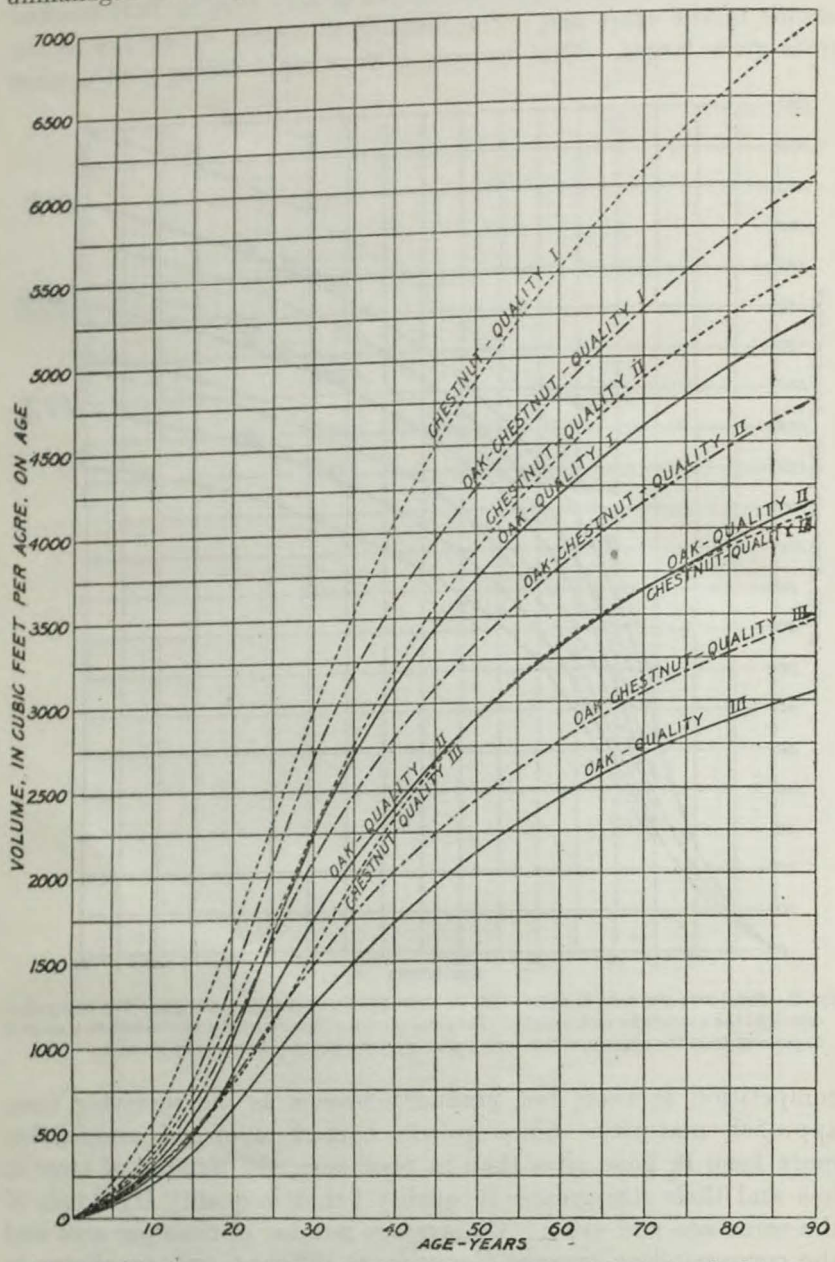
VOLUME, IN CUBIC FEET PER ACRE, ON AGE
AGE-YEARS
CHESTNUT - QUALITY I
OAK-CHESTNUT - QUALITY I
CHESTNUT - QUALITY II
OAK - QUALITY I
OAK-CHESTNUT - QUALITY II
OAK - QUALITY II
CHESTNUT - QUALITY III
OAK-CHESTNUT - QUALITY III
OAK - QUALITY III
OAK - QUALITY II
CHESTNUT - QUALITY III

FIG. 3.—Yield per acre, in cubic feet, for three qualities in chestnut, oak-chestnut, and oak types.

selected from the 268 plot measurements made in the course of the study. The different classes of data were averaged graphically, and from these results were obtained the figures given in the tables. For

convenience the yield tables are separated into general yield tables, and yield tables for cordwood, lumber, ties, and poles. In the general tables and those for cordwood, yields are shown for the oak-chestnut, chestnut, and oak types. In the other tables figures are for chestnut only, since yields in lumber and ties in the oak and oak-chestnut types proved too few and irregular for accurate computation. The actual yields in lumber and ties of such normally stocked plots in these types as were measured are given, however, in Tables 49, 50, 51, and 52 in the Appendix.

### GENERAL.

Tables 17–25, inclusive, show the approximate yield per acre in cubic feet, for five-year periods, of average unmanaged stands of the different types and quality classes. Together with the yield are shown (1) the average height of the dominant or tallest trees in the stand, since this is the basis of the distinction of quality classes; (2) the average diameter of all trees above 2 inches in diameter at breast-height; (3) the total number of trees per acre over 2 inches in diameter; and (4) the total basal area per acre, which determines whether or not a stand is fully stocked.

The yields in cubic feet for living trees were read from the curves in figure 3. The individual plots were scaled by cubic-foot volumes. To obtain the total yield per acre the volumes for merchantable dead trees were scaled by a special table, averaged by a curve, and added to the yield for living trees.

TABLE 17.— *Yield in cubic feet—chestnut type, quality I.*

| Age. | Height of dominant trees. | Diameter breast-high of average tree. | Number of trees per acre. | Basal area per acre. | Yield per acre. | |
|---|---|---|---|---|---|---|
| | | | | | Living trees. | Living and merchantable dead trees. |
| *Years.* | *Feet.* | *Inches.* | | *Sq. ft.* | *Cu. ft.* | *Cu. ft.* |
| 15 | 38 | 3.2 | 1,000 | 56 | 1,090 | 1,150 |
| 20 | 50 | 4.4 | 830 | 88 | 1,660 | 1,750 |
| 25 | 58 | 5.4 | 680 | 108 | 2,310 | 2,420 |
| 30 | 64 | 6.4 | 550 | 122 | 2,960 | 3,100 |
| 35 | 70 | 7.3 | 460 | 133 | 3,550 | 3,680 |
| 40 | 74 | 8.1 | 400 | 142 | 4,050 | 4,220 |
| 45 | 77 | 8.9 | 350 | 150 | 4,490 | 4,700 |
| 50 | 80 | 9.6 | 310 | 157 | 4,880 | 5,150 |
| 55 | 83 | 10.3 | 280 | 163 | 5,220 | 5,500 |
| 60 | 85 | 10.9 | 260 | 169 | 5,530 | 5,800 |
| 65 | 87 | 11.6 | 235 | 173 | 5,830 | 6,070 |
| 70 | 88 | 12.2 | 220 | 177 | 6,100 | 6,320 |
| 75 | 90 | 12.8 | 200 | 181 | 6,350 | 6,530 |

TABLE 18.—*Yield in cubic feet—chestnut type, quality II.*

| Age. | Height of dominant trees. | Diameter breast-high of average tree. | Number of trees per acre. | Basal area per acre. | Yield per acre. | |
|---|---|---|---|---|---|---|
| | | | | | Living trees. | Living and merchantable dead trees. |
| *Years.* | *Feet.* | *Inches.* | | *Sq. ft.* | *Cu. ft.* | *Cu. ft.* |
| 15 | 30 | 2.6 | 1,160 | 43 | 800 | 860 |
| 20 | 40 | 3.6 | 930 | 66 | 1,220 | 1,300 |
| 25 | 48 | 4.5 | 800 | 89 | 1,720 | 1,850 |
| 30 | 54 | 5.3 | 675 | 103 | 2,250 | 2,400 |
| 35 | 60 | 6.1 | 560 | 114 | 2,760 | 2,900 |
| 40 | 64 | 6.8 | 490 | 123 | 3,190 | 3,350 |
| 45 | 68 | 7.5 | 425 | 130 | 3,570 | 3,720 |
| 50 | 71 | 8.2 | 370 | 136 | 3,880 | 4,050 |
| 55 | 74 | 8.8 | 335 | 141 | 4,170 | 4,330 |
| 60 | 76 | 9.4 | 300 | 146 | 4,420 | 4,600 |
| 65 | 77 | 9.9 | 280 | 150 | 4,660 | 4,850 |
| 70 | 79 | 10.5 | 255 | 154 | 4,870 | 5,070 |
| 75 | 80 | 11.0 | 240 | 157 | 5,060 | 5,280 |

TABLE 19.—*Yield in cubic feet—chestnut type, quality III.*

| Age. | Height of dominant trees. | Diameter breast-high of average tree. | Number of trees per acre. | Basal area per acre. | Yield per acre. | |
|---|---|---|---|---|---|---|
| | | | | | Living trees. | Living and merchantable dead trees. |
| *Years.* | *Feet.* | *Inches.* | | *Sq. ft.* | *Cu. ft.* | *Cu. ft.* |
| 15 | 21 | 2.0 | 1,360 | 30 | 520 | 580 |
| 20 | 30 | 2.7 | 1,180 | 47 | 780 | 900 |
| 25 | 37 | 3.5 | 990 | 66 | 1,140 | 1,280 |
| 30 | 44 | 4.3 | 790 | 80 | 1,550 | 1,720 |
| 35 | 50 | 5.0 | 670 | 91 | 1,980 | 2,130 |
| 40 | 55 | 5.6 | 580 | 99 | 2,330 | 2,520 |
| 45 | 59 | 6.2 | 500 | 106 | 2,640 | 2,830 |
| 50 | 62 | 6.8 | 450 | 112 | 2,900 | 3,100 |
| 55 | 64 | 7.3 | 400 | 117 | 3,130 | 3,330 |
| 60 | 67 | 7.8 | 360 | 121 | 3,330 | 3,540 |
| 65 | 68 | 8.3 | 330 | 125 | 3,490 | 3,720 |
| 70 | 70 | 8.7 | 310 | 129 | 3,635 | 3,880 |
| 75 | 71 | 9.2 | 290 | 132 | 3,775 | 4,020 |

TABLE 20.—*Yield in cubic feet—oak-chestnut type, quality I.*

| Age. | Height of dominant trees. | Diameter breast-high of average tree. | Number of trees per acre. | Basal area per acre. | Yield per acre. | |
|---|---|---|---|---|---|---|
| | | | | | Living trees. | Living and merchantable dead trees. |
| *Years.* | *Feet.* | *Inches.* | | *Sq. ft.* | *Cu. ft.* | *Cu. ft.* |
| 15 | 35 | 2.9 | 1,130 | 52 | 810 | 830 |
| 20 | 46 | 4.0 | 910 | 79 | 1,390 | 1,440 |
| 25 | 55 | 4.9 | 750 | 98 | 2,080 | 2,150 |
| 30 | 62 | 5.8 | 610 | 112 | 2,700 | 2,820 |
| 35 | 68 | 6.6 | 525 | 125 | 3,190 | 3,350 |
| 40 | 73 | 7.4 | 455 | 136 | 3,600 | 3,780 |
| 45 | 77 | 8.2 | 400 | 146 | 3,950 | 4,150 |
| 50 | 80 | 8.9 | 360 | 155 | 4,250 | 4,480 |
| 55 | 83 | 9.6 | 320 | 162 | 4,530 | 4,780 |
| 60 | 85 | 10.3 | 290 | 169 | 4,800 | 5,060 |
| 65 | 87 | 10.9 | 270 | 175 | 5,050 | 5,320 |
| 70 | 89 | 11.5 | 250 | 181 | 5,280 | 5,550 |
| 75 | 90 | 12.1 | 235 | 186 | 5,500 | 5,770 |

TABLE 21.—*Yield in cubic feet—oak-chestnut type, quality II.*

| Age. | Height of dominant trees. | Diameter breast high of average tree. | Number of trees per acre. | Basal area per acre. | Yield per acre. | |
|---|---|---|---|---|---|---|
| | | | | | Living trees. | Living and merchantable dead trees. |
| *Years.* | *Feet.* | *Inches.* | | *Sq. ft.* | *Cu. ft.* | *Cu. ft.* |
| 15 | 28 | 2.5 | 1,180 | 40 | 670 | 680 |
| 20 | 38 | 3.3 | 950 | 56 | 1,110 | 1,120 |
| 25 | 46 | 4.1 | 770 | 71 | 1,620 | 1,650 |
| 30 | 52 | 4.8 | 675 | 85 | 2,090 | 2,150 |
| 35 | 57 | 5.5 | 610 | 96 | 2,480 | 2,570 |
| 40 | 61 | 6.1 | 530 | 107 | 2,800 | 2,920 |
| 45 | 65 | 6.7 | 470 | 115 | 3,090 | 3,230 |
| 50 | 68 | 7.3 | 425 | 123 | 3,350 | 3,500 |
| 55 | 71 | 7.8 | 390 | 130 | 3,575 | 3,730 |
| 60 | 73 | 8.4 | 355 | 136 | 3,780 | 3,950 |
| 65 | 75 | 8.9 | 325 | 141 | 3,975 | 4,150 |
| 70 | 77 | 9.4 | 305 | 146 | 4,150 | 4,340 |
| 75 | 78 | 9.8 | 285 | 150 | 4,320 | 4,520 |

TABLE 22.—*Yield in cubic feet—oak-chestnut type, quality III.*

| Age. | Height of dominant trees. | Diameter breast-high of average tree. | Number of trees per acre. | Basal area per acre. | Yield per acre. | |
|---|---|---|---|---|---|---|
| | | | | | Living trees. | Living and merchantable dead trees. |
| *Years.* | *Feet.* | *Inches.* | | *Sq. ft.* | *Cu. ft.* | *Cu. ft.* |
| 15 | 23 | 2.0 | 1,500 | 33 | 515 | ..... |
| 20 | 31 | 2.8 | 1,070 | 46 | 820 | ..... |
| 25 | 38 | 3.3 | 1,000 | 59 | 1,160 | 1,170 |
| 30 | 43 | 3.9 | 855 | 71 | 1,480 | 1,500 |
| 35 | 48 | 4.4 | 755 | 80 | 1,780 | 1,800 |
| 40 | 52 | 4.8 | 700 | 88 | 2,030 | 2,070 |
| 45 | 55 | 5.3 | 620 | 95 | 2,250 | 2,300 |
| 50 | 58 | 5.7 | 570 | 101 | 2,440 | 2,500 |
| 55 | 60 | 6.1 | 525 | 106 | 2,610 | 2,680 |
| 60 | 62 | 6.5 | 475 | 110 | 2,770 | 2,850 |
| 65 | 64 | 6.9 | 445 | 115 | 2,910 | 3,000 |
| 70 | 66 | 7.2 | 420 | 119 | 3,050 | 3,130 |
| 75 | 67 | 7.6 | 390 | 122 | 3,170 | 3,260 |

TABLE 23.—*Yield in cubic feet—oak type, quality I.*

| Age. | Height of dominant trees. | Diameter breast-high of average tree. | Number of trees per acre. | Basal area per acre. | Yield per acre. | |
|---|---|---|---|---|---|---|
| | | | | | Living trees. | Living and merchantable dead trees. |
| *Years.* | *Feet.* | *Inches.* | | *Sq. ft.* | *Cu. ft.* | *Cu. ft.* |
| 15 | 25 | 2.5 | 1,320 | 45 | 600 | 610 |
| 20 | 38 | 3.5 | 960 | 64 | 1,050 | 1,080 |
| 25 | 49 | 4.5 | 740 | 82 | 1,670 | 1,740 |
| 30 | 57 | 5.5 | 575 | 95 | 2,260 | 2,350 |
| 35 | 63 | 6.4 | 475 | 106 | 2,710 | 2,860 |
| 40 | 68 | 7.2 | 405 | 115 | 3,100 | 3,270 |
| 45 | 72 | 8.0 | 350 | 122 | 3,420 | 3,630 |
| 50 | 75 | 8.7 | 310 | 129 | 3,710 | 3,950 |
| 55 | 78 | 9.4 | 280 | 135 | 3,970 | 4,220 |
| 60 | 80 | 10.0 | 260 | 141 | 4,200 | 4,470 |
| 65 | 82 | 10.6 | 240 | 146 | 4,400 | 4,680 |
| 70 | 84 | 11.1 | 220 | 150 | 4,600 | 4,900 |
| 75 | 86 | 11.6 | 210 | 154 | 4,770 | 5,080 |

TABLE 24.—*Yield in cubic feet—oak type, quality II.*

| Age. | Height of dominant trees. | Diameter breast-high of average tree. | Number of trees per acre. | Basal area per acre. | Yield per acre. | |
|---|---|---|---|---|---|---|
| | | | | | Living trees. | Living and merchantable dead trees. |
| *Years.* | *Feet.* | *Inches.* | | *Sq. ft.* | *Cu. ft.* | *Cu. ft.* |
| 15 | 22 | 2.2 | 1,400 | 37 | 480 | 490 |
| 20 | 31 | 3.0 | 1,060 | 52 | 840 | 860 |
| 25 | 40 | 3.9 | 795 | 66 | 1,310 | 1,340 |
| 30 | 47 | 4.6 | 675 | 78 | 1,750 | 1,800 |
| 35 | 53 | 5.3 | 575 | 88 | 2,100 | 2,180 |
| 40 | 57 | 6.0 | 485 | 95 | 2,400 | 2,510 |
| 45 | 61 | 6.6 | 430 | 102 | 2,680 | 2,810 |
| 50 | 64 | 7.1 | 390 | 107 | 2,910 | 3,060 |
| 55 | 67 | 7.6 | 355 | 112 | 3,120 | 3,300 |
| 60 | 68 | 8.1 | 325 | 116 | 3,310 | 3,500 |
| 65 | 70 | 8.5 | 300 | 119 | 3,490 | 3,700 |
| 70 | 72 | 8.9 | 280 | 122 | 3,650 | 3,870 |
| 75 | 73 | 9.4 | 255 | 124 | 3,800 | 4,030 |

TABLE 25.—*Yield in cubic feet—oak type, quality III.*

| Age. | Height of dominant trees. | Diameter breast-high of average tree. | Number of trees per acre. | Basal area per acre. | Yield per acre. | |
|---|---|---|---|---|---|---|
| | | | | | Living trees. | Living and merchantable dead trees. |
| *Years.* | *Feet.* | *Inches.* | | *Sq. ft.* | *Cu. ft.* | *Cu. ft.* |
| 15 | 18 | 1.9 | 1,550 | 31 | 370 | 380 |
| 20 | 25 | 2.5 | 1,290 | 44 | 630 | 640 |
| 25 | 32 | 3.2 | 1,000 | 56 | 950 | 970 |
| 30 | 37 | 3.7 | 880 | 66 | 1,240 | 1,260 |
| 35 | 42 | 4.2 | 770 | 74 | 1,490 | 1,530 |
| 40 | 46 | 4.7 | 650 | 79 | 1,720 | 1,770 |
| 45 | 49 | 5.1 | 560 | 82 | 1,930 | 2,000 |
| 50 | 52 | 5.5 | 515 | 85 | 2,120 | 2,210 |
| 55 | 54 | 5.8 | 480 | 88 | 2,290 | 2,380 |
| 60 | 56 | 6.2 | 430 | 90 | 2,440 | 2,550 |
| 65 | 58 | 6.5 | 400 | 92 | 2,570 | 2,700 |
| 70 | 60 | 6.8 | 275 | 94 | 2,690 | 2,830 |
| 75 | 61 | 7.1 | 345 | 95 | 2,790 | 2,950 |

## CORDWOOD.

The figures given in Table 26 were derived by dividing the yields in cubic feet for the different types, qualities, and average breasthigh diameters at different ages, given in the preceding tables, by the cordwood converting factors—that is, the corresponding number of cubic feet per cord, given in Table 41, Appendix. This method is not entirely accurate, but the results are fairly close to the average for each type and quality class.

TABLE 26.—*Yield per acre in cords—chestnut, oak-chestnut, and oak types.*

| Age. | Chestnut type. | | | Oak-chestnut type. | | | Oak type. | | |
|---|---|---|---|---|---|---|---|---|---|
| | Quality I. | Quality II. | Quality III. | Quality I. | Quality II. | Quality III. | Quality I. | Quality II. | Quality III. |
| *Years.* | | | | | | | | | |
| 15 | 16 | 12 | 9 | 12 | 10 | 8 | 9 | 8 | 6 |
| 20 | 23 | 18 | 13 | 19 | 16 | 12 | 15 | 12 | 10 |
| 25 | 30 | 24 | 18 | 28 | 22 | 17 | 23 | 18 | 14 |
| 30 | 37 | 30 | 23 | 36 | 28 | 20 | 30 | 24 | 17 |
| 35 | 43 | 35 | 27 | 41 | 33 | 24 | 36 | 28 | 21 |
| 40 | 48 | 40 | 31 | 46 | 36 | 27 | 40 | 32 | 24 |
| 45 | 53 | 43 | 34 | 49 | 40 | 30 | 44 | 35 | 26 |
| 50 | 57 | 46 | 37 | 53 | 42 | 32 | 48 | 38 | 29 |
| 55 | 61 | 49 | 39 | 56 | 45 | 33 | 51 | 40 | 30 |
| 60 | 63 | 51 | 41 | 59 | 47 | 35 | 53 | 43 | 32 |
| 65 | 66 | 53 | 42 | 62 | 49 | 37 | 55 | 45 | 34 |
| 70 | 68 | 55 | 44 | 64 | 51 | 38 | 58 | 47 | 35 |
| 75 | 70 | 57 | 45 | 66 | 53 | 39 | 60 | 48 | 36 |

## LUMBER—CHESTNUT TYPE.

To obtain the figures given in Table 27 the individual sample plots were scaled by the board-foot volume Tables 42–44, Appendix, for chestnut and oak. In scaling the plots it was necessarily assumed that every tree large enough for lumber was sound, straight, and clear enough to produce the amount of lumber given in the table for the corresponding diameter and height. The yields must therefore be considered ideal, and should be discounted for a given stand according to the variation in straightness, soundness, and clearness of the timber. Since the trees upon which the volume tables are based were not of the first quality, it is probable that a discount of from 10 to 15 per cent would, in most cases, be sufficient. The yields include, besides chestnut, the proportion of oak lumber, never exceeding 40 per cent, which commonly exists in stands of the chestnut type. The volume in "additional cordwood" is that from trees too small to cut into lumber, and from tops and branches of logged trees, and is derived from the volume in cubic feet of "topwood" given in Tables 42–44, together with the volume in cubic feet of all the trees in the plot under 9 inches diameter breasthigh scaled by Tables 38–40. The resulting total volume per acre in "cubic feet additional" in this and succeeding tables is converted into cords by dividing by 80, the number of solid cubic feet which it was assumed that a cord of small trees, tops, and branches would contain.

TABLE 27.—*Yield per acre in lumber and additional cordwood—chestnut type.*

| Age. | Quality I. | | Quality II. | | Quality III. | |
|---|---|---|---|---|---|---|
| | Lumber.[1] | Additional cordwood. | Lumber.[1] | Additional cordwood. | Lumber.[1] | Additional cordwood. |
| *Years.* | *Bd. ft.* | *Cords.* | *Bd. ft.* | *Cords.* | *Bd. ft.* | *Cords.* |
| 20 | 300 | 21 | ..... | ..... | ..... | ..... |
| 25 | 1,400 | 27 | ..... | ..... | ..... | ..... |
| 30 | 2,850 | 30 | 900 | 27 | ..... | ..... |
| 35 | 5,100 | 29 | 2,100 | 29 | 900 | 24 |
| 40 | 8,200 | 28 | 3,700 | 31 | 1,800 | 26 |
| 45 | 11,000 | 28 | 5,400 | 31 | 2,900 | 26 |
| 50 | 13,800 | 28 | 7,700 | 29 | 4,100 | 26 |
| 55 | 16,500 | 27 | 9,900 | 28 | 5,500 | 25 |
| 60 | 19,100 | 25 | 12,000 | 26 | 7,000 | 24 |
| 65 | 21,600 | 24 | 14,000 | 25 | 8,400 | 22 |
| 70 | 23,900 | 22 | 16,100 | 23 | 9,800 | 21 |
| 75 | 25,700 | 21 | 17,800 | 21 | 11,100 | 19 |

[1] Scaled by the international rule.

## TIES—CHESTNUT TYPE.

Table 28, which shows the yield in ties and additional cordwood, was constructed from Tables 45–47, Appendix, on the same assumptions regarding the stand as in the case of the lumber-yield table. The figures should therefore be discounted for a given stand by a figure varying with the straightness, soundness, and clearness of the timber. The yields are for both chestnut and oak ties. Although the published specifications for ties do not consider black or red oak, these are included for the reason given on page 45. If it is desired to limit the application of the table to white oaks and chestnut, the figures should be discounted by a figure in proportion with the estimated number and size of red and black oaks per acre suitable for ties at the time for which it is desired to determine the yield.

TABLE 28.—*Yield per acre in ties* [1] *and additional cordwood—chestnut type.*

| Age. | Quality I. | | Quality II. | | Quality III. | |
|---|---|---|---|---|---|---|
| | Ties. | Additional cordwood. | Ties. | Additional cordwood. | Ties. | Additional cordwood. |
| *Years.* | *Number.* | *Cords.* | *Number.* | *Cords.* | *Number.* | *Cords.* |
| 25 | 25 | 29 | ..... | ..... | ..... | ..... |
| 30 | 76 | 34 | 20 | 29 | ..... | ..... |
| 35 | 140 | 37 | 55 | 33 | 20 | 25 |
| 40 | 225 | 38 | 100 | 36 | 45 | 28 |
| 45 | 320 | 37 | 150 | 36 | 75 | 30 |
| 50 | 435 | 35 | 215 | 35 | 110 | 31 |
| 55 | 565 | 32 | 290 | 33 | 145 | 31 |
| 60 | 710 | 29 | 365 | 30 | 190 | 30 |
| 65 | 855 | 26 | 440 | 28 | 235 | 29 |
| 70 | 975 | 25 | 510 | 26 | 280 | 28 |
| 75 | 1,075 | 24 | 575 | 25 | 330 | 26 |

[1] All first class—6 by 8 inches by 8 feet.

### POLES—CHESTNUT TYPE.

Table 29 shows the approximate yield per acre in chestnut poles, chestnut and oak ties, and cordwood. It is assumed that all trees which do not come up to the specifications for poles will be cut for ties, and that whatever small trees remain, together with the branches and tops of the felled trees, will be utilized for cordwood. The figures were derived from Volume Tables 45–48, Appendix. As with lumber and ties, the yields given do not take into account the crooked, unsound, and limby trees in the stand, and should be discounted according to the number of these per acre. Owing to the difficulty of stating the length of poles except as an average, it was impossible to include this point in the table.

TABLE 29.— *Yield per acre in poles, and additional ties and cordwood—chestnut type.*

| Age. | Quality I. | | | Quality II. | | | Quality III. | | |
|---|---|---|---|---|---|---|---|---|---|
| | Poles. | Additional ties. | Additional cordwood. | Poles. | Additional ties. | Additional cordwood. | Poles. | Additional ties. | Additional cordwood. |
| *Years.* | *Number.* | *Number.* | *Cords.* | *Number.* | *Number.* | *Cords.* | *Number.* | *Number.* | *Cords.* |
| 30 | 6 | 50 | 34 | ..... | ..... | ..... | ..... | ..... | ..... |
| 35 | 13 | 110 | 37 | 2 | 40 | 33 | ..... | ..... | ..... |
| 40 | 20 | 175 | 38 | 6 | 80 | 36 | ..... | ..... | ..... |
| 45 | 30 | 195 | 37 | 11 | 125 | 36 | ..... | ..... | ..... |
| 50 | 41 | 185 | 35 | 18 | 170 | 35 | 3 | 80 | 31 |
| 55 | 55 | 150 | 32 | 25 | 185 | 33 | 7 | 115 | 31 |
| 60 | 71 | 115 | 29 | 33 | 180 | 30 | 12 | 160 | 30 |
| 65 | 90 | 60 | 26 | 42 | 175 | 28 | 17 | 175 | 29 |
| 70 | 105 | ..... | 25 | 51 | 160 | 26 | 22 | 175 | 28 |
| 75 | 117 | ..... | 24 | 59 | 145 | 25 | 26 | 170 | 26 |

## HOW TO USE THE YIELD TABLES.

The determination of the future yield of a stand is necessarily somewhat complicated, but it should be done by every owner of woodland who is interested in the potential value of his property.

The first step in the application of yield tables is to determine the age, type, and quality of the stand in question. In most cases the age is known to the owner or to old residents in the vicinity; if not, it can be ascertained with sufficient accuracy by counting the rings on a stump of a felled tree. The tree selected for this purpose should be among the dominant ones, since these have usually been pioneers in the formation of young stands. The type can usually be told by the approximate proportions of oak and chestnut in the stand. The quality class to which the stand belongs can be found by estimating or measuring the height of one or more of the dominant trees, and comparing the result with the heights given in the yield table for the age class nearest to that of the stand. The probable yield of the stand at present and for any five-year period in the future can then be read from the tables for the proper type and quality class.

Since the yield tables are for normally stocked stands only, as described on pages 31–33, they can not be relied upon to foretell yields of over or under stocked stands. Whether or not a stand is fully stocked

can be judged with sufficient accuracy by inspection. If the crowns are moderately full and occupy more than three-fourths of the available space, and the trunks are of relatively good diameter and without large branches, the stand may be considered normally stocked. Stands in which the crowns occupy less than three-fourths of the growing space, and in which the trunks are relatively short, thick, and limby, are understocked; while in overstocked stands the crowns are small or crowded, and the trunks slender.

## GROWTH OF STANDS.

In connection with the growth of stands three questions must usually be answered: First, what has been the average growth per year from the establishment of the stand up to the present; second, how rapidly is it growing now, and is this rate slower or faster than it has been or is likely to be; and third, how do these rates of growth in a stand of a given type and quality compare with those of stands of the same age, but belonging to other types and quality classes? Answers to these questions, as determined for average, even-aged hardwood stands in Connecticut, are given in Tables 30–33. The figures in the columns headed "Average annual growth" are simply the yields taken from the yield tables, divided by the age of the stand in years. The "Periodic annual growth" is the average annual growth for a given period (in this case five years). It therefore shows the approximate rate at which a stand of a given type and quality class will grow during any given period in its life, and is of great importance in determining the length of rotation. (See p. 48.)

These tables bring out two facts of importance in the management of even-aged stands. First, the rate both of the average annual and the periodic annual growth varies with the age, the type, and the quality class. It is most rapid in quality I chestnut and slowest in quality III oak. Second, at a certain point in the life of a stand the growth reaches a maximum and then falls off. The point of culmination of the average annual growth in lumber, ties, and poles for the chestnut type does not come until after the seventy-fifth year, and so is not shown in the tables.

TABLE 30.—*Average annual growth per acre by quality classes—chestnut type.*

| Age. | Cubic feet. | | | Cords. | | | Board feet. | | | Ties. | | | Poles. | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | I. | II. | III. | I. | II. | III. | I. | II. | III. | I. | II. | III. | I. | II. | III. |
| *Years.* | | | | | | | | | | | | | | | |
| 15 | 72.7 | 53.3 | 34.7 | 1.03 | 0.80 | 0.55 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| 20 | 83.5 | 61.3 | 39.3 | 1.09 | .84 | .58 | 15 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| 25 | 92.4 | 68.8 | 45.6 | 1.14 | .89 | .63 | 56 | ..... | ..... | 1.0 | ..... | ..... | ..... | ..... | ..... |
| 30 | 98.7 | 75.0 | 51.7 | *1.18* | .94 | .68 | 95 | 30 | ..... | 2.5 | 0.7 | ..... | 0.20 | ..... | ..... |
| 35 | *101.5* | 78.9 | 56.4 | *1.18* | *.95* | .71 | 146 | 60 | 26 | 4.0 | 1.6 | 0.6 | .37 | 0.06 | ..... |
| 40 | 101.3 | *79.8* | 58.4 | 1.14 | .94 | *.72* | 205 | 93 | 45 | 5.6 | 2.5 | 1.1 | .50 | .15 | ..... |
| 45 | 99.8 | 79.4 | *58.7* | 1.12 | .92 | .70 | 247 | 122 | 64 | 7.1 | 3.3 | 1.7 | .67 | .24 | ..... |
| 50 | 97.5 | 77.7 | 58.0 | 1.08 | .88 | .69 | 276 | 152 | 82 | 8.7 | 4.3 | 2.2 | .82 | .36 | 0.06 |
| 55 | 95.0 | 75.9 | 56.9 | 1.04 | .85 | .66 | 302 | 180 | 100 | 10.3 | 5.3 | 2.6 | 1.00 | .45 | .13 |
| 60 | 92.2 | 73.8 | 55.5 | 1.01 | .82 | .64 | 322 | 202 | 115 | 11.8 | 6.1 | 3.2 | 1.18 | .55 | .20 |
| 65 | 89.7 | 71.8 | 53.7 | .97 | .79 | .61 | 334 | 218 | 129 | 13.2 | 6.8 | 3.6 | 1.39 | .65 | .26 |
| 70 | 87.1 | 69.6 | 51.9 | .94 | .76 | .58 | 341 | 231 | 141 | 13.9 | 7.3 | 4.0 | 1.50 | .73 | .31 |
| 75 | 84.7 | 67.6 | 50.4 | .90 | .74 | .56 | 343 | 241 | 153 | 14.3 | 7.7 | 4.4 | 1.56 | .79 | .35 |

TABLE 31.—*Periodic annual growth per acre by quality classes—chestnut type.*

| Age. | Cubic feet. | | | Cords. | | | Board feet. | | | Ties. | | | Poles. | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | I. | II. | III. | I. | II. | III. | I. | II. | III. | I. | II. | III. | I. | II. | III. |
| *Years.* | | | | | | | | | | | | | | | |
| 20 | 114 | 85 | 53 | 1.49 | 1.16 | 0.78 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| 25 | *130* | 99 | 71 | *1.61* | 1.29 | .98 | 220 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| 30 | *130* | *106* | 82 | 1.55 | *1.32* | 1.08 | 290 | ..... | ..... | 10 | ..... | ..... | ..... | ..... | ..... |
| 35 | 118 | 102 | *85* | 1.37 | 1.23 | *1.08* | 450 | 240 | ..... | 13 | 7 | ..... | 1.4 | ..... | ..... |
| 40 | 100 | 86 | 72 | 1.14 | 1.02 | .89 | *626* | 320 | 180 | 17 | 9 | 5 | 1.4 | 0.8 | ..... |
| 45 | 87 | 76 | 61 | .98 | .88 | .73 | 580 | *540* | 220 | 19 | 10 | 6 | 2.0 | 1.0 | ..... |
| 50 | 78 | 67 | 52 | .87 | .76 | .61 | 560 | 460 | 240 | 23 | 13 | 7 | 2.2 | 1.4 | ..... |
| 55 | 69 | 58 | 46 | .76 | .65 | .54 | 540 | 440 | 280 | 26 | *15* | 7 | 2.8 | 1.4 | 0.8 |
| 60 | 62 | 52 | 40 | .68 | .58 | .46 | 520 | 420 | *300* | *29* | *15* | 9 | 3.2 | 1.6 | *1.0* |
| 65 | 58 | 47 | 32 | .63 | .52 | .36 | 500 | 400 | 280 | *29* | *15* | 9 | *3.8* | *1.8* | *1.0* |
| 70 | 54 | 42 | 29 | .58 | .46 | .33 | 460 | 380 | 280 | 24 | 14 | 9 | 3.0 | *1.8* | *1.0* |
| 75 | 50 | 39 | 28 | .53 | .42 | .31 | 360 | 340 | 260 | 20 | 13 | 10 | 2.4 | 1.6 | .8 |

TABLE 32.—*Annual growth per acre by quality classes—oak-chestnut type.*

| Age. | Average annual growth. | | | | | | Periodic annual growth. | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Cubic feet. | | | Cords. | | | Cubic feet. | | | Cords. | | |
| | I. | II. | III. | I. | II. | III. | I. | II. | III. | I. | II. | III. |
| *Years.* | | | | | | | | | | | | |
| 15 | 54.0 | 44.3 | 34.4 | 0.79 | 0.67 | 0.55 | ..... | ..... | ..... | ..... | ..... | ..... |
| 20 | 69.5 | 55.5 | 41.0 | .94 | .80 | .60 | 116 | 89 | 61 | 1.57 | 1.26 | 0.90 |
| 25 | 83.0 | 64.8 | 46.4 | 1.08 | .87 | .66 | *137* | *102* | *68* | *1.79* | *1.37* | *.97* |
| 30 | 90.0 | 69.7 | 49.3 | *1.13* | *.91* | .67 | 105 | 94 | 64 | 1.32 | 1.23 | .87 |
| 35 | *91.2* | *70.9* | *51.1* | 1.12 | .90 | *68* | 98 | 78 | 60 | 1.21 | .99 | .80 |
| 40 | 90.0 | 70.0 | 50.7 | 1.09 | .87 | .66 | 82 | 64 | 50 | .99 | .80 | .66 |
| 45 | 87.8 | 68.7 | 50.0 | 1.04 | .85 | .64 | 70 | 58 | 44 | .83 | .71 | .56 |
| 50 | 85.0 | 67.0 | 48.8 | 1.00 | .81 | .62 | 60 | 52 | 38 | .71 | .63 | .48 |
| 55 | 82.5 | 65.0 | 47.5 | .96 | .78 | .59 | 57 | 45 | 34 | .66 | .54 | .42 |
| 60 | 80.0 | 63.0 | 46.3 | .93 | .75 | .57 | 54 | 41 | 32 | .63 | .49 | .39 |
| 65 | 77.7 | 61.2 | 44.8 | .90 | .72 | .55 | 50 | 39 | 28 | .58 | .46 | .34 |
| 70 | 75.4 | 59.3 | 43.6 | .87 | .69 | .53 | 46 | 35 | 26 | .53 | .41 | .32 |
| 75 | 73.3 | 57.7 | 42.3 | .84 | .67 | .51 | 44 | 35 | 24 | .51 | .41 | .29 |

TABLE 33.—*Annual growth per acre by quality classes—oak type.*

| Age. | Average annual growth. | | | | | | Periodic annual growth. | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Cubic feet. | | | Cords. | | | Cubic feet. | | | Cords. | | |
| | I. | II. | III. | I. | II. | III. | I. | II. | III. | I. | II. | III. |
| *Years.* | | | | | | | | | | | | |
| 15 | 40.0 | 32.0 | 25.0 | 0.61 | 0.50 | 0.40 | ..... | ..... | ..... | ..... | ..... | ..... |
| 20 | 52.5 | 42.0 | 31.5 | .73 | .61 | .48 | 90 | 72 | 51 | 1.26 | 1.04 | 0.77 |
| 25 | 66.8 | 52.4 | 38.0 | .89 | .71 | .54 | *124* | *94* | *64* | *1.65* | *1.28* | *.92* |
| 30 | 75.3 | 58.3 | 41.3 | *.97* | .77 | *.57* | 118 | 88 | 58 | 1.52 | 1.17 | .80 |
| 35 | *77.5* | *60.0* | 42.6 | *.97* | *.78* | *.57* | 91 | 70 | 50 | 1.14 | .91 | .67 |
| 40 | *77.5* | *60.0* | *43.1* | .96 | .76 | *.57* | 77 | 60 | 46 | .95 | .76 | .61 |
| 45 | 76.0 | 59.5 | 42.9 | .93 | .74 | .56 | 65 | 55 | 41 | .79 | .69 | .54 |
| 50 | 74.2 | 58.2 | 42.4 | .90 | .72 | .55 | 57 | 47 | 38 | .69 | .58 | .49 |
| 55 | 72.3 | 56.7 | 41.6 | .87 | .70 | .53 | 52 | 42 | 34 | .62 | .51 | .43 |
| 60 | 70.0 | 55.2 | 40.7 | .83 | .67 | .51 | 46 | 38 | 30 | .55 | .46 | .38 |
| 65 | 67.7 | 53.7 | 39.6 | .80 | .65 | .49 | 41 | 36 | 26 | .48 | .44 | .33 |
| 70 | 65.7 | 52.1 | 38.4 | .77 | .63 | .48 | 38 | 32 | 23 | .45 | .39 | .29 |
| 75 | 63.7 | 50.7 | 37.2 | .75 | .61 | .46 | 35 | 30 | 20 | .41 | .36 | .25 |

## PART IV.—MANAGEMENT.

Under management are included the various methods of handling woodlands by which it is sought to secure, in comparison with unmanaged forests, either greater returns in the same number of years or the same return in less time.

The essential factors in the management of second-growth stands are: (1) species; (2) the rotation, or the number of years through which the stand should be allowed to grow; (3) thinnings, to increase the yield and improve the quality of the stand; (4) the final cutting, to secure immediate, complete, and satisfactory natural reproduction; (5) methods of changing the composition of a stand from one species or set of species to another of greater value; (6) the regeneration of worn-out sprout woods by introducing healthy seedlings; and (7) protection.

### CHOICE OF SPECIES.

The owner of natural woodland is allowed no choice of the species with which to begin management, but must do the best he can with those which predominate in the stand. In the process of management, however, it is possible to alter radically the composition of the stand by judicious thinnings and the methods described under the heading, "Changing the type." Whether a species is suitable or not depends upon its relative thrift under the prevailing soil conditions; its security against disease, insect attack, etc.; the market for it; its rate of growth; and the possibility of introducing it by silvicultural means.

Chestnut, because of its rapid growth and the good market open to it, would be by far the best species to favor in suitable situations, were it not for its susceptibility to the chestnut-bark disease. This disease, if unchecked, promises entirely to wipe out the chestnut from at least a large part of the State, and for this reason management of the species is at best a hazardous undertaking. In cuttings it will often be necessary, therefore, to restrict its reproduction as much as possible, and to favor that of oaks or other species not subject to the disease. The methods by which this may be accomplished are discussed on page 56.

The "black oaks"—including black or "yellow" oak, red oak, and scarlet oak—are not in great demand for ties or poles, owing to their lack of durability in contact with the soil, and an excellent market is thus practically closed to them. They are, however, well adapted to certain situations, are rapid growers, and would produce excellent yields under proper management. Red oak, especially, does exceedingly well on good chestnut soils, where its growth is often nearly equal

to that of chestnut. Black and scarlet oaks are more suited to the dry soils of the oak and oak-chestnut types, where, in fact, they must usually remain predominant. The oaks have the great advantage that they are not subject to any serious disease of a widely epidemic nature. The wood can be treated with chemical preservatives at small cost, and it is very probable that in the future preservative methods will greatly increase the scope of these species' usefulness.

The "white oaks"—white oak and chestnut or "rock" oak— are in wide demand for ties and lumber, owing to their strength and durability. They are not susceptible to serious injury from disease, except in isolated cases, but, on the other hand, grow very slowly and require a long time to produce any material other than cordwood. Chestnut oak is well adapted to dry soils, and its superior sprouting ability fits it for management as sprout woods on dry, ridgy land of low value.

Hickory, red maple, dogwood, and other hardwood species commonly occur in second-growth stands of all types and qualities. They usually occupy a subordinate position in the stand, where they form an important and valuable source of cordwood. Hickory, while in great demand in the wagon and tool-handle industries, is of very slow growth, and does not do well enough in the State to warrant its management as the principal tree of a stand. Other species, such as white and red pine and yellow poplar, are particularly desirable for management in suitable soils, but their discussion lies outside the scope of this bulletin.

## FACTORS INFLUENCING ROTATION.

In deciding upon the length of rotation to be adopted the four most important considerations are: (1) The method by which it is planned to reproduce the stand; (2) the kind of material to be obtained; (3) the time at which the average annual growth culminates for any given kind of material; and (4) the time when the stand, if cut, would yield the highest net money return.

### METHOD OF REPRODUCING THE STAND.

The reproduction by sprouts of chestnut and oak stands in Connecticut has proved so simple and easy a method that it will probably continue to be the one most practiced in the State. Its influence upon the choice of a rotation has to do with the danger of delaying the cut until the stand passes the age of vigorous sprout production. In chestnut stands this danger is not serious, since the trees will usually produce vigorous sprouts even if not cut until 75 years old or even later.

Nevertheless, while the vigor of sprouting from such stands may be as great as it would be if the final cutting were made earlier, the density of the sprouts may be much less, since at the age of 75 years there will be fewer trees, and consequently fewer stumps. This may result in understocking and the development of limby or crooked trees of small value except for cordwood.

Oaks decrease in sprouting capacity much earlier than chestnut, and should therefore be cut earlier. Of the oaks found in Connecticut, chestnut or "rock" oak probably retains its sprouting ability for the longest time. A maximum rotation of 45 years might be used for this species with fair hope of securing satisfactory sprout reproduction. For the other species of oak, rotations of more than 25 or 35 years could probably not be depended upon to result in good stands of sprouts. Under long rotations many of the stumps would utterly fail to produce sprouts, while most of those which did sprout would tend to produce only relatively weak and inferior saplings.

Repeated clear cuttings of a sprout stand will ultimately reduce its sprouting capacity and the rate of growth of the sprouts, and increase its susceptibility to disease. The treatment under such conditions is outlined on page 57 under the subject of "Regenerating worn-out sprout stands."

In old stands containing a preponderance of oak, reproduction must necessarily be secured by natural seeding, with or without assistance by planting. In such cases rotation may be of any length indicated by the other factors, except that in stands under 40 or 50 years old seed production is likely to be too scanty to insure good reproduction after cutting.

### CHOICE OF MATERIAL.

What kind of material it will be best to grow, whether cordwood, lumber, ties, or poles, will depend upon market conditions, illustrated for the present time in Tables 9 to 16, and upon the number of years necessary to produce each kind, as shown in the yield tables. There is little prospect of more than a temporary decline in the value of any of the standard products of Connecticut woodlands, and the stumpage values given in Part II may therefore be safely taken as conservative.

Tables 34 and 35 show how to apply the stumpage values given in Tables 10, 12, 14, and 16 to the yield tables in order to obtain the approximate stumpage value per acre in cordwood, lumber, ties, and poles. The case is that of a quality II chestnut stand, 4 miles from market (2 trips per day haul), and with teaming wage rates at $5 per day. Table 34 is based on a market value for cordwood of $4.50, while in Table 35 it is $5. This is the only difference. The tables

show at a glance what are the most remunerative products.[1] They also show the immense difference in the stumpage value per acre caused by the comparatively slight difference of 50 cents in market value of cordwood. This affects the stumpage value per acre of the other products, owing to the inclusion of the "additional cordwood."

While the chief purpose of these tables is to show the wide differences in the value of a wood lot used for different purposes, they also bring out graphically the relation between stumpage and profit. This is most striking in the case of cordwood in Table 34. With a market value of $4.50 per cord, the stumpage value per acre, for a 4-mile haul, is almost negligible. The profit which the operator would have to receive to make his investment pay 20 per cent is very much greater. If he wished to receive this profit he could not afford to pay more for his stumpage than the amount indicated in the stumpage column. In the case of the other materials, the amounts given for stumpage value and profit cover not only the lumber, ties, or poles but also the additional cordwood left in tops, branches, and small trees. It should be remembered that the profit is figured on the total investment, including both the expenditure for stumpage and that for the total logging operation from stump to market.

TABLE 34.—*Stumpage values per acre*[2] *of different materials, when the price of cordwood is $4.50, for quality II chestnut, by five-year periods.*

[For a stand 4 miles from market, 2 trips per day, with teaming wage rate of $5 per day.]

| Age. | Cordwood, at $4.50 per cord. | | Lumber, at $18 per M board feet and additional cordwood. | | First-class ties, at 50 cents apiece and additional cordwood. | | Poles, at $4.10 apiece with additional ties and cordwood. | |
|---|---|---|---|---|---|---|---|---|
| | Stumpage, 4 cents per cord. | 20 per cent profit, 75 cents per cord. | Stumpage, $4.13 per M. | 20 per cent profit, $3 per M. | Stumpage, 15 cents per tie. | 20 per cent profit, 8 cents per tie. | Stumpage, $2.44 per pole. | 20 per cent profit, 68 cents per pole. |
| *Years.* | | | | | | | | |
| 15 | $0.50 | $9.00 | ..... | ..... | ..... | ..... | ..... | ..... |
| 20 | .70 | 13.50 | ..... | ..... | ..... | ..... | ..... | ..... |
| 25 | 1.00 | 18.00 | ..... | ..... | ..... | ..... | ..... | ..... |
| 30 | 1.20 | 22.50 | $4.80 | $23.00 | $4.10 | $23.40 | ..... | ..... |
| 35 | 1.40 | 26.30 | 9.80 | 28.10 | 9.50 | 29.30 | $12.10 | $29.40 |
| 40 | 1.60 | 30.00 | 16.50 | 34.40 | 16.20 | 35.30 | 27.90 | 37.80 |
| 45 | 1.70 | 32.30 | 23.50 | 39.50 | 23.60 | 39.50 | 46.70 | 44.90 |
| 50 | 1.80 | 34.50 | 33.00 | 44.90 | 33.20 | 44.10 | 70.50 | 52.70 |
| 55 | 2.00 | 36.80 | 42.00 | 50.70 | 44.20 | 48.90 | 89.70 | 57.30 |
| 60 | 2.00 | 38.30 | 50.50 | 55.50 | 55.20 | 52.80 | 108.30 | 60.00 |
| 65 | 2.10 | 39.80 | 58.80 | 60.80 | 66.20 | 57.50 | 129.50 | 64.20 |
| 70 | 2.20 | 41.30 | 67.40 | 65.50 | 76.50 | 61.90 | 149.20 | 67.70 |
| 75 | 2.30 | 42.80 | 74.30 | 69.20 | 86.10 | 66.50 | 166.50 | 71.20 |

[1] These figures should not be depended upon in any specific case. While they are based on approximately average yield data and logging costs, individual costs may vary considerably from them. In the acre values for poles, 35-foot poles are assumed in each case, though the average length would undoubtedly be less for young and greater for old stands. It should also be borne in mind that the yield tables for ties, lumber, and poles are based on the assumption of straight and sound timber, and do not take account of crookedness or decay.

[2] These are the money equivalents of the yield tables for quality II chestnut, and are based on the stumpage values given in Tables 10, 12, 14, and 16, to secure a profit of 20 per cent on the combined investment in stumpage and logging.

TABLE 35.—*Stumpage values per acre*[1] *of different materials, when the price of cordwood is $5, for quality II chestnut, by five-year periods.*

[For a stand 4 miles from market, 2 trips per day, with teaming wage rate of $5 per day.]

| Age. | Cordwood, at $5 per cord. | | Lumber, at $18 per M board feet and additional cordwood. | | First-class ties, at 50 cents apiece and additional cordwood. | | Poles, at $4.10 apiece, with additional ties and cordwood. | |
|---|---|---|---|---|---|---|---|---|
| | Stumpage, 46 cents per cord. | 20 per cent profit, 83 cents per cord. | Stumpage, $4.13 per M. | 20 per cent profit, $3 per M. | Stumpage, 15 cents per tie. | 20 per cent profit, 8 cents per tie. | Stumpage, $2.44 per pole. | 20 per cent profit, 68 cents per pole. |
| *Years.* | | | | | | | | |
| 15 | $5.50 | $10.00 | ..... | ..... | ..... | ..... | ..... | ..... |
| 20 | 8.00 | 15.00 | ..... | ..... | ..... | ..... | ..... | ..... |
| 25 | 11.00 | 20.00 | ..... | ..... | ..... | ..... | ..... | ..... |
| 30 | 13.80 | 25.00 | $16.10 | $25.10 | $16.30 | $25.70 | ..... | ..... |
| 35 | 16.10 | 29.00 | 22.00 | 30.40 | 23.30 | 32.00 | $26.00 | $32.10 |
| 40 | 18.40 | 33.20 | 29.60 | 36.90 | 31.40 | 38.20 | 43.10 | 40.60 |
| 45 | 19.80 | 35.70 | 36.60 | 42.00 | 38.80 | 42.30 | 61.90 | 47.80 |
| 50 | 21.20 | 38.20 | 45.10 | 47.20 | 47.90 | 47.00 | 85.20 | 55.50 |
| 55 | 22.60 | 40.70 | 53.80 | 52.90 | 58.10 | 51.50 | 103.60 | 59.90 |
| 60 | 23.50 | 42.40 | 61.50 | 57.60 | 67.80 | 55.20 | 120.90 | 62.40 |
| 65 | 24.40 | 44.00 | 69.30 | 62.80 | 78.00 | 59.70 | 141.30 | 66.40 |
| 70 | 25.30 | 45.70 | 77.10 | 67.35 | 87.50 | 64.00 | 160.20 | 69.80 |
| 75 | 26.25 | 47.30 | 83.20 | 70.80 | 96.60 | 68.50 | 177.00 | 73.17 |

[1] These are the money equivalents of the yield tables for quality II chestnut, and are based on the stumpage values given in Tables 10, 12, 14, and 16, to secure a profit of 20 per cent on the combined investment in stumpage and logging.

## CULMINATION OF THE AVERAGE ANNUAL GROWTH.

The higher the average yearly production of a piece of woodland, the greater of course will be its continuous producing value if cut over repeatedly. The ages at which the average annual growth in cubic feet and cords culminates are indicated by italic figures in Tables 30, 32, and 33. From the tables it is apparent that if a woodland is to be cut over repeatedly for cordwood, the greatest amount will be secured if the cutting is made at the following ages:

| | Years. |
|---|---|
| Chestnut, qualities I and II | 35 |
| Chestnut, quality III | 40 |
| Oak-chestnut, qualities I and II | 30 |
| Oak-chestnut, quality III | 35 |
| Oak, qualities I and II | 35 |
| Oak, quality III | 40 |

These lengths of rotation are so nearly similar that it is safe to place the cordwood rotation for second-growth hardwood stands at from 30 to 40 years. To insure successful sprout reproduction the rotation for stands containing much red, black, or scarlet oak should be 30 or even 25 years, though the latter period may involve a sacrifice of from 3 to 5 cords per acre. In stands of chestnut oak the rotation may be as long as 40 years.

For lumber, ties, and poles, in the chestnut type, the rotation may be as long as 75 years. In many cases other considerations, such as depreciation of the stand, will call for shorter rotations, but not without a sacrifice in the continuous producing capacity of the land.

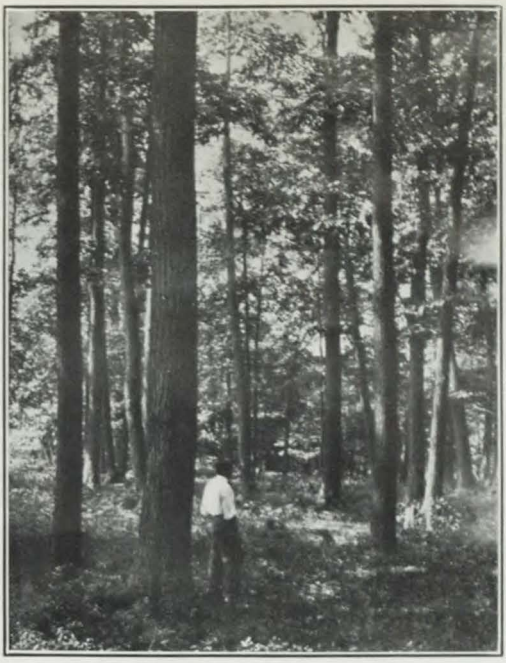

FIG. 1.—STAND OF CHESTNUT SPROUTS AND SEEDLINGS, 90 TO 100 YEARS OLD.

FIG. 2.—MODERATE THINNING IN 35-YEAR-OLD QUALITY I CHESTNUT.

About 10 cords per acre were removed in 1908.

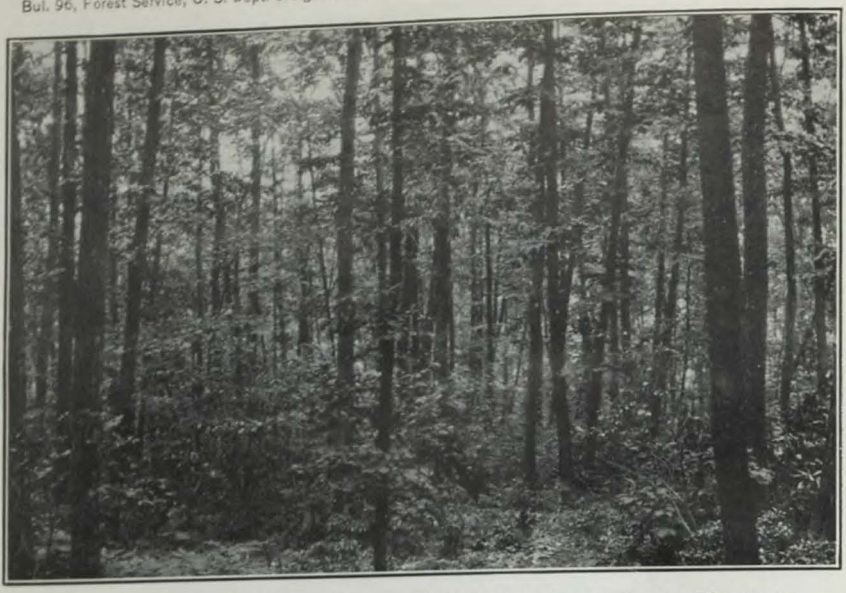

FIG. 1.—FORTY-FIVE-YEAR-OLD QUALITY II CHESTNUT STAND BEFORE THINNING.

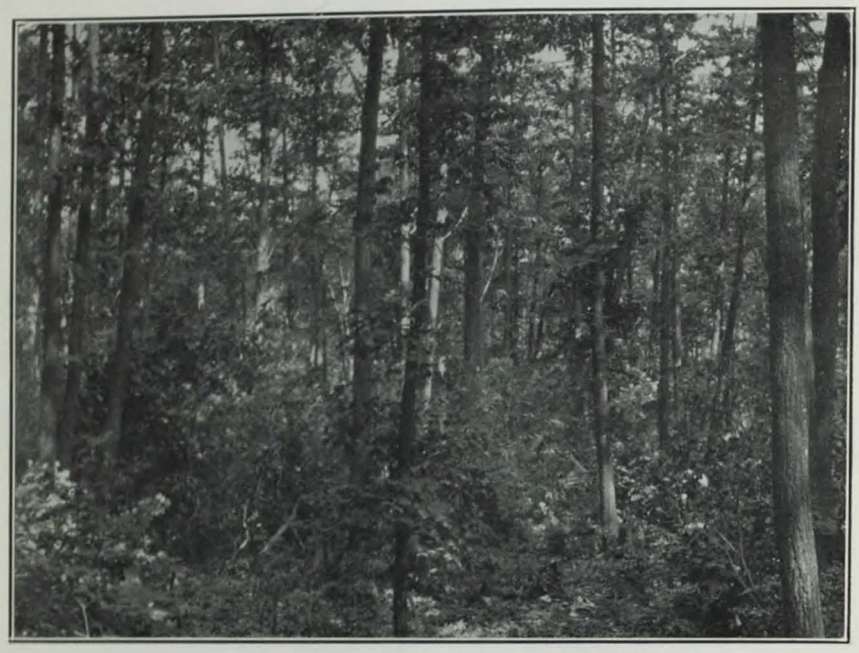

FIG. 2.—SAME STAND AFTER THINNING.

Eight and one-half cords per acre were removed.

### GREATEST INCOME.

The greatest volume production of a stand does not necessarily correspond with the highest net income. The accumulation at compound interest of taxes, interest on the investment, and other outlays may prevent a heavy average yearly production of material on a long rotation from yielding as large a net return as a shorter rotation and a smaller mean annual growth. The conditions with regard to taxation and investment vary so widely that it is not practicable to discuss them in this report. Every owner should consider them, however, in the management of his woodland.

## THINNINGS.

A stand of timber is much more valuable if its volume is contained in a few large, well-formed trees than if it is distributed among many small trees. The aim of thinning, therefore, is to throw the whole volume of growth of the stand into only as many of the best trees as will fully utilize the growing space. This is done by removing all other trees that seriously interfere with them. Furthermore, if the proper trees are selected for removal and the thinnings made at right intervals they will not only yield a direct money return, but will result in maintaining at the maximum the volume growth of the trees left without interfering with the production of long, clear trunks.

### OBJECT OF THINNINGS.

Since it is in the leaves that the food of the tree is manufactured, any increase in the amount of foliage will increase the food supply, and thereby the rate of growth. Leaves need a certain amount of sunlight in order to manufacture food, and are not produced in those portions of the tree which receive insufficient light. Thinnings, therefore, stimulate volume growth by opening up the stand and allowing more leaves to be produced on the trees left than would be possible if they were crowded by their neighbors.

While the volume growth of stands is stimulated by opening them up, their height growth is greatest if the trees are moderately crowded. The period of most rapid height growth in oak and chestnut stands is during youth, and the rate of growth ordinarily begins to decrease between the twentieth and thirtieth years. During this period a moderate crown shade prevents the growth of lower branches, and all the energy of the tree is directed toward its growth upward. Occasionally, however, the crown shade during this period is so heavy that the individual trees are unable to produce enough leaves even for a rapid height growth. In such stands thinnings are especially desirable. Since during youth the remaining crowns rapidly expand

and fill the openings left, moderate thinnings may be conducted at this time without much danger of seriously interfering with the rate of height growth. Thinnings in young stands of average density may be made with advantage as soon as it is apparent that the number of cords of merchantable wood which can be removed without unduly opening up the stand is sufficient to pay the cost of thinning.

If too much of the stand is removed, leaving the remaining trees in more or less isolated positions, the volume growth, while greatly accelerated, will take place largely in the branches, giving the tree a bushy appearance. There is a medium grade in thinning, however, whereby the growth may be stimulated without resulting in the development of large branches. In chestnut and oak stands this is when the crown cover is opened up to an extent that the trees left will fill up the openings within a period of about five years. Except in young stands this ordinarily means increasing the space between the crowns by from 3 to 5 feet. Often it is necessary to leave even more space, as when a large diseased tree has been removed; but even then little damage to the form of the neighboring trees is likely to result, while the growth increase will be correspondingly greater or more prolonged. In all except very young stands thinnings will remove enough wood not only to pay for the thinning but to yield a profit.

### TIME AND SEVERITY.

Thinnings should be begun early in the life of the stand and continued at 5 or 10 year intervals until it is mature and ready to be cut clear. It is better to thin lightly and often than heavily and at longer intervals. The amount to be removed in thinnings in general depends upon the age, type, quality, and density of the stand and the chief products desired. In young stands more trees per acre should be removed than in older ones of the same type or quality, though the per cent of volume cut may be no greater. Thinnings may be heavier in chestnut stands on fertile soil where the trees grow rapidly and straight than in chestnut or oak stands on poorer sites. When fuel wood is to be the product thinnings should be the heaviest, since in this case there is no objection to the abundant protection of branches, the one essential being to utilize every bit of the growing space. Heavy thinnings will also result in the rapid production of short logs suitable for ties. The long clear trunks necessary for poles and lumber are best produced in well-closed stands, and thinnings should be light.

In 18 typical thinnings made in the course of this and former studies in Connecticut, the amount removed varied from 20 to 40 per cent of the cubic volume. Most thinnings will fall between these extremes. Damage from chestnut blight, fire, or insects may sometimes necessitate much heavier thinnings than would otherwise be desirable, and "damage cuttings" may often exceed 50 per cent of

the cubic volume. Thinnings of this kind result in many large openings in the crown cover, and every effort should be made to leave enough of the smaller trees and undergrowth to fill the openings and protect the soil. The approximate amount of wood obtainable in thinnings of a given degree of severity can easily be found for stands of different ages and qualities by computing the required per cent (20 to 40 per cent) of the cubic foot yields given in Tables 17 to 25. It should be remembered that while more trees are removed in thinning young stands than in thinning older ones, the actual volume of wood secured is not as great, and hence the labor cost per cord is greater.

### TREES REMOVED.

In discussing thinnings it is convenient to classify the trees in a stand as "dominant," "codominant," "intermediate," "overtopped," and "dead." These divisions are termed "crown classes," and may be readily observed in any unthinned woodlot. The dominant are the conspicuously tallest and most thrifty trees. The codominant trees may be as tall, but do not have such well-developed crowns. Intermediate trees are those which form the lower part of the crown cover; not as tall as the dominant or codominant, but whose crowns still receive light from above. The overtopped trees are those which are shaded from above by their neighbors. They may be either flourishing trees of shade-enduring species, such as maple, black birch, hickory, or hemlock, or else suppressed individuals of light-needing species, like chestnut, which will soon die from lack of light. Dead trees are always present in large numbers in the average uncared-for woodlot. In this discussion, however, dead trees include only those with a merchantable value for cordwood.

Aside from dead trees, which may always be removed, no tree should be cut merely because it belongs to a certain crown class. Thus it may often be desirable to remove an unthrifty codominant or even dominant tree in preference to one or more adjacent intermediate trees of better promise. No definite rule will fit all cases, and the removal of individual trees is largely a matter of judgment. In general, all trees should be removed which are either unnecessary or actually harmful to the stand by interfering with the development of better trees, or by endangering the spread of disease.

The trees should be favored in the order of the crown classes; that is, there should be taken out first the merchantable dead trees, next the overtopped, then some of the intermediate, while as many as possible of the thrifty codominant and dominant trees should be left standing. Since enough living trees must be left to shade the soil and keep out weeds it may often be necessary to leave some of the overtopped trees. Large openings in the stand should always be avoided.

Table 36 shows the number of trees removed and the yield in cubic feet secured in four actual thinnings. In each case all the merchantable dead wood was removed, but in the third example a previous cutting had taken most of the dead trees. The yield in cubic feet can be reduced approximately to cords by dividing by 80. The average amount of merchantable dead wood obtainable from previously unthinned stands of various ages can be obtained from Tables 17 to 25 by deducting the yield in living wood from that in living and merchantable dead wood.

TABLE 36.—*Number of trees and volume of wood per acre removed in thinning four stands, by crown classes.*

NUMBER OF TREES REMOVED PER ACRE.

| Type. | Age—years. | Total. | | Dominant. | | Codominant. | | Intermediate. | | Overtopped. | | Dead; removed. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Removed. | Left. | Removed. | Left. | Removed. | Left. | Removed. | Left. | Removed. | Left. | |
| Chestnut: | | | | | | | | | | | | |
| Quality III.. | 25-30 | 384 | 316 | 8 | 104 | 28 | 92 | 108 | 88 | 172 | 32 | 68 |
| Do ..... | 45 | 432 | 216 | 4 | 124 | 56 | 52 | 40 | 20 | 124 | 20 | 208 |
| Quality II... | 45 | 120 | 252 | ..... | 148 | 16 | 80 | 56 | ..... | 44 | 20 | 8 |
| Oak: | | | | | | | | | | | | |
| Quality III.. | 46 | 372 | 352 | 16 | 184 | 16 | 84 | 68 | 68 | 140 | 16 | 132 |

VOLUME OF WOOD REMOVED PER ACRE.

| Type. | Age—Years. | Total removed. | | Total left. | | Proportion of amount removed. | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Dominant. | Codominant. | Intermediate. | Overtopped. | Dead. | Total. |
| | | Cubic feet. | Per cent. | Cubic feet. | Per cent. | Per cent. | Per cent. | Per cent. | Per cent. | Per cent. | Per cent. |
| Chestnut: | | | | | | | | | | | |
| Quality III.. | 25-30 | 428 | 30 | 1,008 | 70 | 14 | 24 | 31 | 24 | 7 | 100 |
| Do..... | 45 | 1,243 | 38 | 2,036 | 62 | 2 | 29 | 15 | 16 | 38 | 100 |
| Quality II... | 45 | 682 | 18 | 3,135 | 82 | ..... | 22 | 57 | 17 | 4 | 100 |
| Oak: | | | | | | | | | | | |
| Quality III.. | 46 | 553 | 28 | 1,404 | 72 | 11 | 10 | 24 | 21 | 34 | 100 |

RESULTS OF THINNINGS.

There are many even-aged stands in Connecticut which have not been cut clear, but from which many of the larger trees have been removed for poles or ties. These stands sometimes show to a remarkable degree the effect of increased light in stimulating the growth of the trees left. In a 46-year-old quality I chestnut stand, examined in the course of the study, a heavy cutting for ties had been made 14 years before, when the stand was 32 years old. All trees over 10 inches in diameter which would make a tie were removed, and the rest of the stand left. At the time of the examination the larger trees of the stand, now 46 years old, had just been cut for poles.

The elapsed 14 years had thus been sufficient, with the large increase in light and growing space from the tie culling, for their growth not only to tie size, but to the much more valuable dimension of large poles. A measurement of the rings of annual growth on the stumps of the trees thus cut for poles gave the results shown in Table 37.

TABLE 37.—*Increase in growth at the stump, resulting from removal of the largest trees. (Chestnut type, quality I, 46 years old, thinned 14 years before; area about 3 acres.)*

| Stump diameter class. | Average diameter inside bark at time of— | | Average width of ring. | | Diameter at time of cutting if original rate of growth had continued. | Increase[1] in rate of average annual growth in volume as result of thinning. | Basis. |
|---|---|---|---|---|---|---|---|
| | Thinning. | Final cutting. | Before thinning. | After thinning. | | | |
| *Inches.* | *Inches.* | *Inches.* | *Inches.* | *Inches.* | *Inches.* | *Per cent.* | *Stumps.* |
| 12 | 7.8 | 12.4 | 0.13 | 0.19 | 11.3 | 3.1 | 1 |
| 13 | 7.9 | 13.0 | .12 | .19 | 11.3 | 4.7 | 3 |
| 14 | 9.4 | 13.9 | .15 | .18 | 13.5 | 0.9 | 6 |
| 15 | 9.3 | 15.0 | .14 | .22 | 13.3 | 4.0 | 19 |
| 16 | 9.6 | 16.0 | .15 | .24 | 13.7 | 5.3 | 9 |
| 17 | 9.6 | 16.9 | .15 | .24 | 13.7 | 7.6 | 6 |
| 18 | 9.8 | 18.2 | .16 | .30 | 14.2 | 9.6 | 11 |
| 19 | 7.2 | 18.8 | .11 | .39 | 10.3 | 34.0 | 1 |
| 20 | 8.2 | 20.2 | .16 | .30 | 12.7 | 26.2 | 2 |
| 21 | 11.1 | 21.5 | .17 | .40 | 15.8 | 12.3 | 1 |

[1] Derived by means of the formula:

$$I = \frac{(c-b)\,100}{n \times a}$$

Where I = per cent of increase in rate of average annual growth in area, as a result of thinning:
a = surface area of stump at time of thinning;
b = greatest possible surface area 14 years after thinning if original rate of growth had continued;
c = actual surface area 14 years after thinning;
n = interval between thinning and final cutting—in this case 14 years.
These percentage figures are directly applicable to volume growth if the total height and form factor are constant. This assumption is made in the above column.

With the heights and form factors of the trees constant, it is evident from Table 37 that the yearly growth in volume increased by from 1 to 34 per cent as a result of thinning. Since the percentages of increase given in the table are based upon the average growth before thinning and not on the actual rate at which the trees were growing when the thinning was made, they may be taken as conservative. As a matter of fact, the faces of the stumps showed that during a period, varying with individual trees, of from 8 to 19 years just preceding the thinning the rate of growth had been considerably slower than before. This shows that the trees had begun to be crowded or more or less suppressed by their neighbors. It is probable that even if the trees had survived this competition during the 14 succeeding years they would have increased very little in diameter. By the removal of their larger neighbors, however, they were enabled to put forth new foliage in such abundance that their subsequent growth was more than doubled. Though their growth in height may not have been quite so rapid as in a denser stand, it was nevertheless sufficient to produce excellent poles.

The example cited shows that good results may be obtained from a system of thinning in which, instead of removing the small trees, the largest ones in the stand are taken. This method of cutting lends itself to stands in which there is a market for only the larger trees. Unless very carefully used, however, it is very likely to result in a distinct decrease in the ultimate productivity of an area. The danger of overcutting is great, while the removal of the dominant trees is sure to damage more or less the intermediate and overtopped ones.

## FINAL CUTTING AND REPRODUCTION.

On land which is to be devoted permanently to forest the final cutting should be considered only an intermediate step in a continuous process. The principles which determine when the final cutting should be made have already been discussed under "Rotation." There remain to be considered the best methods of cutting to secure abundant reproduction of desirable species, and means of renewing the vigor of sprout stands.

### CLEAR-CUTTING SYSTEM.

The common practice in Connecticut of cutting hardwood stands clear is in a majority of cases the best that could be adopted. It is relatively cheap and simple, and when done at the right time, is followed at once by satisfactory reproduction.

The chief incentive to clear cutting in Connecticut has been the fact that it is usually possible to market the entire yield of the stand, if not in certain kinds of material, then in other kinds. Whether or not this can be done really determines the practicability of clear cutting, and should always be ascertained beforehand. Few woodlands in Connecticut are so far from market that poles, ties, or lumber have no stumpage value, and even in the case of remote stands there is often a local market which yields a slight profit on the posts, rails, and cordwood left after logging. Where length of haul prohibits the disposal of cordwood, charcoal may yet be burned to complete the utilization of the stand. If it is impossible to dispose of cordwood or other minor products, cutting can not, of course, be practiced, and the method described on pages 52-54 (Table 37) may be adopted.

If it is planned to reproduce the stand by sprouts, the season of the year in which the final cutting is made is of great importance. Cutting should always be done during the season of "vegetative rest," from late fall to early spring. Cuttings made during this time of the year are far more likely to result in good stands than if made during the "vegetative season"—late spring and summer—after the nour-

ishment stored over winter in the roots has risen in the sap. Summer-cut stumps often produce weak sprouts, which are still too tender when frost comes to withstand it.

Much waste may be prevented by cutting stumps low. Where sprout reproduction is desired the stumps should be left with smooth surfaces, and should be cut at a sufficient angle to allow water to drain off. Care should be taken not to strip the bark from the stump, since this injures or destroys the sprout-producing buds, besides facilitating decay.

To lessen danger from fire and to restore to the soil food elements taken from it by the tree, all branches too small for use should be lopped so that they will lie flat, and then scattered in order to hasten decay. The wood should either be removed at once or piled along roads, and not hauled through the woods later among tender sprouts.

### POLE-WOOD SPROUT SYSTEM.

In spite of the simplicity of the clear-cutting system it can be recommended only where there is a reasonable certainty of abundant and evenly distributed reproduction. Failure in this respect is most likely to occur in the oak and oak-chestnut types, and in old chestnut stands where a complete stand of sprouts can not be depended upon. In such cases it is necessary to insure enough seedling reproduction to fill in the spaces not occupied by sprouts. The best way to do this is by "the pole-wood sprout system," in which the stand is removed in two cuttings. The first cutting resembles a heavy thinning and leaves more than half the stand well distributed over the area as a source of seed supply. The second cutting is made 5 or 10 years later, or as soon as seedlings have appeared in sufficient abundance to complete the scattered sprout reproduction from the stumps of the first cutting. If the second cutting is too long delayed, both sprouts and seedlings will suffer from the shade of the standing trees.

In the first cutting the inferior and suppressed trees are removed, as well as those of undesirable species. Portions of the stand which can be counted on to furnish complete sprout reproduction—as clumps of thrifty young chestnut—should be cut clean; elsewhere the thinning should be as uniform as possible.

The second cutting should be clean, unless it is desired to leave a few scattered, thrifty trees for the production of large timber. In removing the stand care should be taken not to injure the undergrowth of sprouts and seedlings.

The cost of cutting and getting out the wood under this method will be somewhat greater than under clear cutting, but where satisfactory sprout reproduction is uncertain this additional expense will be justified by the better reproduction secured.

### CHANGING THE TYPE.

While chestnut is in many respects the best species for woodlot management, the danger of infection from the chestnut blight is at present so great that it will often be desirable to replace it with other species. In stands of pure chestnut, with their persistent sprouting capacity, there is little likelihood of accomplishing this economically. Even if the chestnut were effectually prevented from sprouting after being cut, the expense of planting or sowing the area with other species would probably be prohibitive.

The composition of mixed stands of chestnut and other species, however, can be materially altered. The best way to do this is through a modification of the pole-wood sprout system, in which the first cutting leaves all the chestnut, together with enough seed-bearing trees of the preferred species, to insure satisfactory reproduction. By deferring the removal of the chestnut the usual dense and rapid growth of chestnut sprouts will be delayed, and the seedlings and sprouts of the preferred species given a much better chance to suppress them when they do appear. When the ground is stocked with thrifty young growth the seed trees should be felled, but the chestnut left until the young growth is of sufficient height to maintain itself successfully against the rapid-growing chestnut sprouts. Seed reproduction from chestnut is normally so scant that there is little danger from this source.

The fact that sprouting is less vigorous after summer cutting than after winter cutting suggests another method of controlling the composition of the succeeding stand. This is to cut during the summer the species which it is not desired to reproduce, reserving the desirable species for winter cutting. By this method it may be possible to eliminate or greatly reduce, if necessary, the chestnut in oak-chestnut stands. If the cutting is made during a good seed year for oak, the openings resulting from removal of the chestnut will stock with oak seedlings. Similarly, in mixed stands of white pine and hardwoods, good pine reproduction may be expected if the logging is done during the summer of a pine seed year, and a few of the seed-bearing pines are left standing. An instance of this is illustrated in Plate IX, figure 2. It is often advisable, where a change of type is desired, to leave a few seed trees of the preferred species. The number per acre, depending on the lightness of the seed, will vary from 2 or 3 for white pine to 10 or 20 for oak. These should be removed as soon as reproduction becomes well established. If sprouts start from stumps in sufficient numbers to choke out the seedlings, they should be cut during the summer.

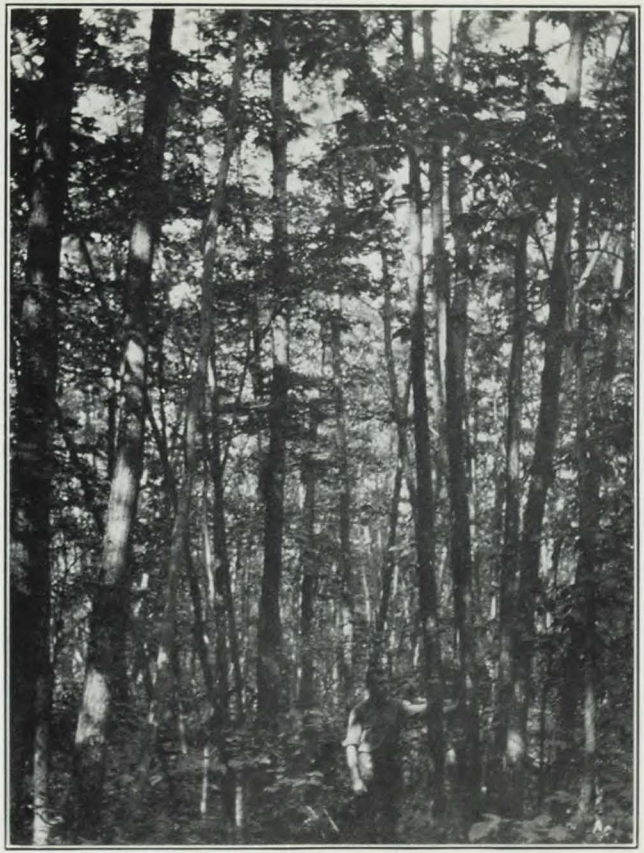

FIG. 1.—FORTY-FIVE-YEAR-OLD QUALITY III CHESTNUT STAND BEFORE THINNING.

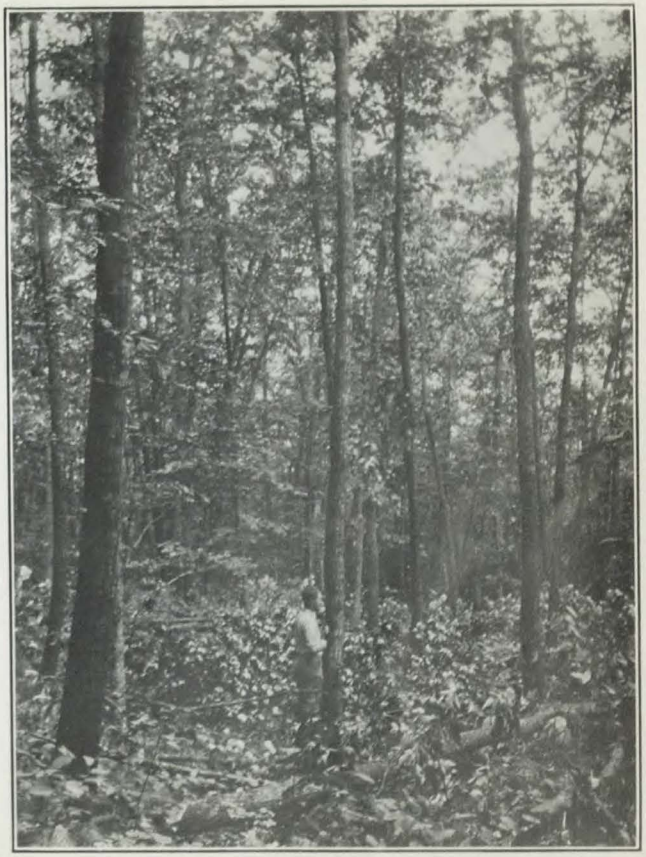

FIG. 2.—SAME STAND AFTER A HEAVY THINNING. ABOUT 15 CORDS PER ACRE WERE REMOVED.

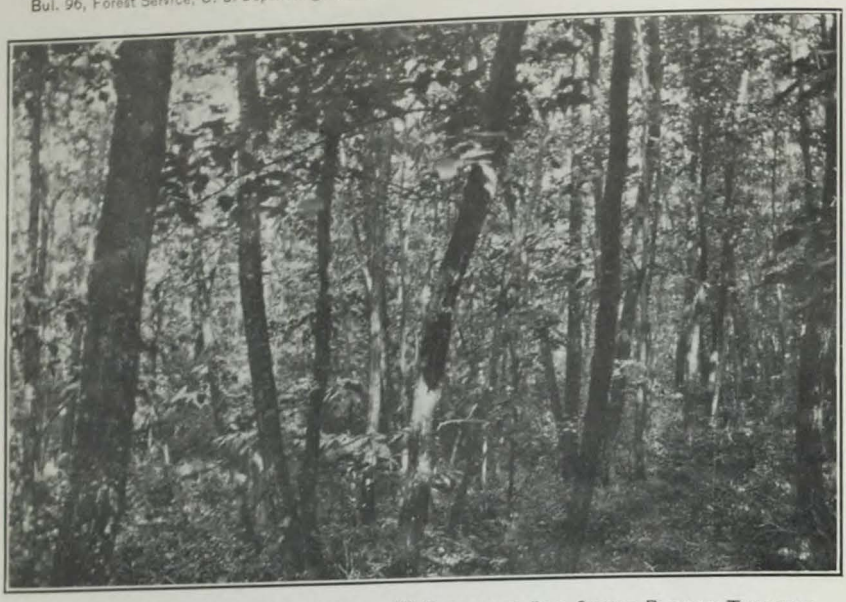

FIG. 1.—FORTY-FIVE-YEAR-OLD QUALITY III CHESTNUT OAK STAND BEFORE THINNING.

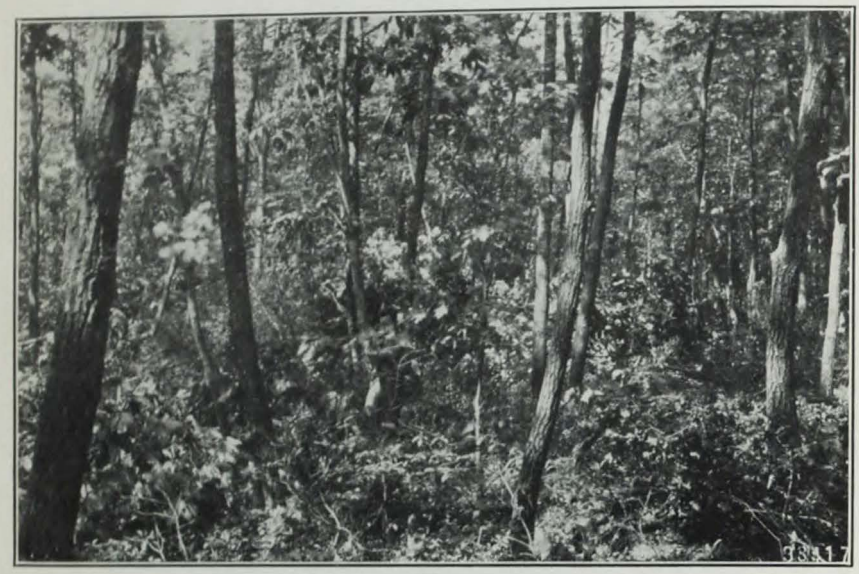

FIG. 2.—SAME STAND AFTER THINNING.

Seven cords per acre were removed.

### REGENERATING WORN-OUT SPROUT STANDS.

After a stump has produced several rotations of sprouts it gradually loses its sprout-producing capacity. This is largely due to the decay of the original root system of the tree, from which the sprouts drew much of their nourishment, as well as decay of the successive root systems of the sprouts themselves. Stands which in the beginning produce the best and most rapid-growing sprouts will, with successive cutting, gradually lose in rate of growth and thrift until they become practically worthless. Such stands often fail entirely to produce sprouts, because their slow growth prevents them from being cut for cordwood or other uses until after the maximum age limit for sprout production. Many more successive crops can be obtained from chestnut than from oak; but even chestnut stands ultimately become worn out and in need of renewing.

To regenerate worn-out stands it is necessary to secure a reproduction of seedlings. This may be accomplished either naturally, by leaving seed trees on the area, or artificially, by sowing or planting. Often a combination of the two methods is advisable, the second supplementing the first. The final cutting should in this case be made in summer, in order to discourage sprouting from the cut stumps. Where the growth of sprouts threatens the seedlings, light surface burning just previous to the seed fall or planting, especially if brush is piled and burned on the smaller stumps, will be effective. Burning should always be conducted when there is the least danger of the fire spreading, and should be kept constantly under control. Except in the case cited, the use of fire should be avoided, since it destroys the surface layer of decaying leaves and humus.

If natural reproduction is supplemented with planting or sowing, a change of type may be made at the same time. Thus white pine seed may be sown broadcast, or seedlings planted, in the spring following the cutting. Planting is the preferred method. In general it is much better to replace worn-out hardwood forests with conifers than to supplement meager reproduction by artificial planting of slow-growing hardwood species. If hardwoods are preferred, acorns or chestnuts may be sown in spots over the area, preferably from 4 to 6 feet apart. Three or four should be placed in each seed spot and buried not over an inch deep. Black, red, and scarlet oak acorns are not liked by squirrels, chipmunks, etc., but white and chestnut oak acorns and chestnuts are likely to be consumed. These should therefore be sown in the spring [1] and the area thoroughly poisoned by depositing over it small amounts of wheat soaked in a

[1] The method of storing acorns for the winter is described in Forest Service Circular 106.

solution of strychnine. This can be done with little danger to stock or birds if the deposits are left in tile drain tubes, in small covered boxes, under bowlders, etc.[1]

## PROTECTION.

Protection from fire is obviously essential to the success of management. Even light surface fires, if repeated, scar the bases of the trees, permitting the entrance of decay-producing fungi. In addition, they destroy the surface layer of humus, which acts as a mulch against the evaporation of moisture and contains valuable food materials for the stand. Danger from fire may be greatly reduced by preventing the accumulations of inflammable débris, as described on page 55. A dangerous practice is that of piling brush, cut from the edges of public highways, along the borders of woodlands, where it dries out and is easily ignited. Contrary to a common belief, the presence of living underbrush of the usual kinds is not a serious menace. The best protection from fire lies in the hearty cooperation of towns and landowners in enforcing the State fire laws.

Measures for the prevention and control of forest fires are discussed in Bulletin 6 of the Connecticut Agricultural Experiment Station, which may be obtained on application to the State forester.

## FINANCIAL RETURNS.

Since management will involve different expenses and returns in different localities and kinds of stands, only a brief summary of the more general items which must be taken into account will be given.

Every expense in management must be warranted by either an immediate or a later financial return, and all operations must not only pay for themselves but must also yield a profit on the investment. In the case of thinnings the profit may be both direct, on the material removed, and indirect, in increased growth of the trees left. If the direct return from material removed in thinning is insufficient entirely to pay the expense, the difference is almost certain to be more than made up by the increased value of the trees left. Thinnings should therefore involve the least expense compatible with the best growth of the stand. The removal of underbrush and valueless dead trees is a needless expense without any compensating return either in money or, in most cases, advantage to the stand.

Final cutting is, of course, the most remunerative operation, but to secure the most desirable reproduction, as previously described, it must often be done in a way to sacrifice immediate financial returns.

[1] This subject is discussed at length in Circular 78 of the Biological Survey, "Seed-eating Mammals in Relation to Reforestation," by Ned Dearborn, and in Forest Service Bulletin 98, "Reforestation on the National Forests," by W. T. Cox.

The amount of this sacrifice and the compensating advantages should be weighed beforehand.

The costs of planting or sowing when either is done are a direct outlay, yielding a return only in the trees removed in thinning and at the final cutting. This cost should be figured at compound interest for the length of the rotation and deducted from the estimated value of the stand, or the latter should be discounted to the present, including the value of the thinnings, and the present cost of planting subtracted from it. Since the investment is a long-time one and offers good security if protection from fire is assured, the rate of interest chargeable should not exceed 3 or 4 per cent.

Proper protection of the stand involves a slight annual outlay, which should not exceed 2 or 3 cents per acre. This amount, together with accrued taxes at the prevailing rate, both at compound interest, must be deducted from the total money yield per acre at the end of the rotation.

Stands which have been well managed, with properly made thinnings and cut under suitable rotations, will yield ultimate money returns considerably greater than unmanaged stands. On the other hand, injudicious management tends toward reduced returns, possibly less than might be secured without management.

# APPENDIX.

## VOLUME TABLES.

The tables which follow show the volumes in different kinds of material for trees of different sizes, and are based on over 400 measurements of felled trees made in Connecticut, together with 552 similar measurements made in New York. The stands selected were average ones of approximately second quality, and the figures may therefore slightly underrun for first quality and overrun for third quality. In either case, however, the discrepancy will probably be small.

Since volume tables give the average of large numbers of measurements, they can not be expected to be accurate for individual trees, but only for numbers of trees growing in well-stocked stands. In applying the tables, the diameters of the trees in a stand, or measured portion of a stand, should be calipered or estimated, to give the number of trees per acre of each inch diameter class. The average total height of trees of each diameter should then be estimated to the nearest 10 feet. The total volume for each inch class can then be found by multiplying the figure given in the table for the corresponding height by the number of trees. The sum of these products, placed on an acre basis, gives the total yield per acre of the stand.

### CUBIC FEET.

The volumes in cubic feet given in Tables 38, 39, and 40 include stem and top wood, with bark, up to a minimum diameter of 2 inches. Average stump heights vary from 6 inches for small trees to 21 inches for large ones.

TABLE 38.—*Volume of chestnut in cubic feet.*

| Diameter breast-high. | Height of tree—feet. | | | | | | | | Total basis. |
|---|---|---|---|---|---|---|---|---|---|
| | 20 | 30 | 40 | 50 | 60 | 70 | 80 | 90 | |
| | Volume. | | | | | | | | |
| *Inches.* | *Cu. ft.* | *Cu. ft.* | *Cu. ft.* | *Cu. ft.* | *Cu. ft.* | *Cu. ft.* | *Cu. ft.* | *Cu. ft.* | *Trees.* |
| 2 | 0.2 | 0.3 | ..... | ..... | ..... | ..... | ..... | ..... | 8 |
| 3 | .4 | .7 | 0.9 | ..... | ..... | ..... | ..... | ..... | 23 |
| 4 | ..... | 1.2 | 1.6 | 2.1 | ..... | ..... | ..... | ..... | 12 |
| 5 | ..... | 1.9 | 2.6 | 3.3 | ..... | ..... | ..... | ..... | 8 |
| 6 | ..... | ..... | 3.7 | 4.6 | 5.6 | ..... | ..... | ..... | 15 |
| 7 | ..... | ..... | 5.0 | 6.2 | 7.3 | ..... | ..... | ..... | 18 |
| 8 | ..... | ..... | 6.5 | 7.9 | 9.4 | 11.0 | ..... | ..... | 16 |
| 9 | ..... | ..... | 8.4 | 10.1 | 11.8 | 13.6 | ..... | ..... | 5 |

TABLE 38.—*Volume of chestnut in cubic feet*—Continued.

| Diameter breast-high. | Height of tree—feet. | | | | | | | | Total basis. |
|---|---|---|---|---|---|---|---|---|---|
| | 20 | 30 | 40 | 50 | 60 | 70 | 80 | 90 | |
| | Volume. | | | | | | | | |
| *Inches.* | *Cu. ft.* | *Cu. ft.* | *Cu. ft.* | *Cu. ft.* | *Cu. ft.* | *Cu. ft.* | *Cu. ft.* | *Cu. ft.* | *Trees.* |
| 10 | ..... | ..... | 10.5 | 12.5 | 14.5 | 16.6 | 17.8 | 19.0 | 4 |
| 11 | ..... | ..... | 12.8 | 15.3 | 17.9 | 20.7 | 22.5 | 24.3 | 9 |
| 12 | ..... | ..... | 15.4 | 18.4 | 21.5 | 25.0 | 27.4 | 30.0 | 9 |
| 13 | ..... | ..... | 18.2 | 21.7 | 25.2 | 29.1 | 32.1 | 35.3 | 11 |
| 14 | ..... | ..... | ..... | 25.0 | 29.2 | 33.8 | 37.7 | 41.3 | 17 |
| 15 | ..... | ..... | ..... | 28.8 | 33.6 | 38.8 | 43.4 | 48.0 | 6 |
| 16 | ..... | ..... | ..... | 32.6 | 38.1 | 44.0 | 49.5 | 55.0 | 14 |
| 17 | ..... | ..... | ..... | 36.5 | 42.7 | 49.5 | 56.0 | 63.0 | 6 |
| 18 | ..... | ..... | ..... | 40.5 | 47.4 | 55.5 | 63.0 | 70.5 | 11 |
| 19 | ..... | ..... | ..... | 44.3 | 51.4 | 61.5 | 70.0 | 79.0 | 6 |
| 20 | ..... | ..... | ..... | 49.0 | 58.5 | 68.5 | 78.0 | 88.0 | 4 |
| 21 | ..... | ..... | ..... | ..... | 65.0 | 75.5 | 86.0 | 97.0 | 3 |
| 22 | ..... | ..... | ..... | ..... | 71.0 | 83.0 | 95.0 | 106.5 | 4 |
| 23 | ..... | ..... | ..... | ..... | 78.0 | 91.0 | 104.0 | 117.0 | 5 |
| 24 | ..... | ..... | ..... | ..... | 85.5 | 99.5 | 114.0 | 128.0 | 2 |
| 25 | ..... | ..... | ..... | ..... | 93.0 | 108.5 | 124.0 | 140.0 | 2 |
| Total | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | 218 |

Volumes include stem and top wood, with bark, up to a minimum diameter of 2 inches. Average stump heights vary from 6 inches for small trees to 21 inches for large ones.

TABLE 39.—*Volume of red, black, and scarlet oak, in cubic feet.*

| Diameter breast-high. | Height of tree—feet. | | | | | | | Total basis. |
|---|---|---|---|---|---|---|---|---|
| | 20 | 30 | 40 | 50 | 60 | 70 | 80 | |
| | Volume. | | | | | | | |
| *Inches.* | *Cu. ft.* | *Cu. ft.* | *Cu. ft.* | *Cu. ft.* | *Cu. ft.* | *Cu. ft.* | *Cu. ft.* | *Trees.* |
| 2 | 0.3 | 0.4 | ..... | ..... | ..... | ..... | ..... | 26 |
| 3 | ..... | .9 | 1.0 | ..... | ..... | ..... | ..... | 55 |
| 4 | ..... | 1.5 | 2.0 | 2.6 | ..... | ..... | ..... | 54 |
| 5 | ..... | 2.4 | 2.9 | 3.6 | ..... | ..... | ..... | 46 |
| 6 | ..... | ..... | 4.2 | 5.0 | 6.0 | ..... | ..... | 38 |
| 7 | ..... | ..... | 5.7 | 6.6 | 7.6 | 8.9 | ..... | 36 |
| 8 | ..... | ..... | 7.0 | 8.5 | 10.2 | 12.0 | ..... | 11 |
| 9 | ..... | ..... | 8.7 | 10.9 | 13.0 | 15.2 | 17.3 | 16 |
| 10 | ..... | ..... | 10.5 | 13.1 | 15.7 | 18.4 | 21.0 | 24 |
| 11 | ..... | ..... | 13.0 | 16.0 | 19.0 | 22.1 | 25.2 | 35 |
| 12 | ..... | ..... | 16.4 | 19.7 | 22.8 | 26.2 | 29.3 | 33 |
| 13 | ..... | ..... | 21.0 | 24.3 | 27.7 | 31.0 | 34.3 | 30 |
| 14 | ..... | ..... | 25.3 | 29.0 | 32.6 | 36.3 | 40.0 | 13 |
| 15 | ..... | ..... | 30.2 | 34.2 | 38.1 | 42.0 | 45.8 | 12 |
| 16 | ..... | ..... | ..... | 40.0 | 44.1 | 48.2 | 52.4 | 5 |
| 17 | ..... | ..... | ..... | ..... | ..... | 54.6 | 59.1 | 4 |
| 18 | ..... | ..... | ..... | ..... | ..... | 61.0 | 66.0 | 2 |
| 19 | ..... | ..... | ..... | ..... | ..... | 68.0 | 74.0 | 1 |
| Total | ..... | ..... | ..... | ..... | ..... | ..... | ..... | 441 |

Volumes include stem and topwood, with bark, up to a minimum diameter of 2 inches. Average stump heights vary from 6 inches for small trees to 21 inches for large ones.

TABLE 40.—*Volume of white and chestnut oak, in cubic feet*

| Diameter breast-high. | Height of tree—feet. | | | | | | | Total basis. |
|---|---|---|---|---|---|---|---|---|
| | 20 | 30 | 40 | 50 | 60 | 70 | 80 | |
| | Volume. | | | | | | | |
| *Inches.* | *Cu. ft.* | *Cu. ft.* | *Cu. ft.* | *Cu. ft.* | *Cu. ft.* | *Cu. ft.* | *Cu. ft.* | *Trees.* |
| 2 | 0.3 | 0.4 | ..... | ..... | ..... | ..... | ..... | 26 |
| 3 | ..... | .9 | 1.0 | ..... | ..... | ..... | ..... | 55 |
| 4 | ..... | 1.5 | 2.0 | 2.6 | ..... | ..... | ..... | 54 |
| 5 | ..... | 2.4 | 2.9 | 3.6 | ..... | ..... | ..... | 46 |
| 6 | ..... | ..... | 4.2 | 5.0 | 6.0 | ..... | ..... | 38 |
| 7 | ..... | ..... | 5.7 | 6.6 | 7.6 | 8.9 | ..... | 36 |
| 8 | ..... | ..... | 7.4 | 8.7 | 10.3 | 12.2 | ..... | 10 |
| 9 | ..... | ..... | 9.3 | 11.1 | 13.5 | 16.0 | 18.9 | 2 |
| 10 | ..... | ..... | 11.2 | 13.7 | 16.5 | 19.5 | 22.6 | 8 |
| 11 | ..... | ..... | 13.3 | 16.5 | 19.8 | 23.2 | 26.8 | 14 |
| 12 | ..... | ..... | 15.7 | 19.3 | 23.1 | 27.2 | 31.4 | 1 |
| 13 | ..... | ..... | ..... | 22.4 | 26.9 | 31.5 | 36.3 | 2 |
| 14 | ..... | ..... | ..... | 25.9 | 31.0 | 36.3 | 41.6 | 1 |
| 15 | ..... | ..... | ..... | ..... | 35.5 | 41.7 | 48.1 | ..... |
| 16 | ..... | ..... | ..... | ..... | 40.5 | 47.5 | 55.0 | ..... |
| Total | ..... | ..... | ..... | ..... | ..... | ..... | ..... | 293 |

Volumes include stem and topwood, with bark, up to a minimum diameter of 2 inches. Average stump heights vary from 6 inches for small trees to 21 inches for large ones.

## CORDWOOD.

In place of a volume table for cordwood, a table of cordwood converting factors (Table 41) showing the number of cubic feet per cord by inch diameter classes, breast-high, is given.

To obtain these factors, the average solid-wood contents of a large number of stacked cords—128 cubic feet—of mixed round and split 4-foot wood was determined by adding together the volumes in cubic feet of the sticks composing them. The average middle diameter outside bark of the sticks in each stack was obtained at the same time. The volumes in split wood were determined by measuring the sticks before they were split. On the basis of these figures a curve was drawn on cross-section paper, from which the average solid contents for cords composed of round or split sticks varying in diameter from 0.9 to 10.6 inches were read. To apply these factors to trees of any breast-high diameter, it was necessary simply to determine the average middle diameter outside bark of all the 4-foot sticks into which the tree could be cut.

The figures are conservative, since they represent a larger number of cubic feet per cord than would probably be obtained in the average stack of mixed hardwoods, including branchwood, and in practice would therefore probably slightly underrun the actual cordwood volume.

The converting factors were used in the construction of the cordwood yield table (Table 26) and of the growth tables (Tables 30–33).

In each case the yield per acre in cubic feet was divided by the converting factor corresponding to the breast-high diameter of the average tree in the stand.

TABLE 41.—*Converting factors for second-growth hardwoods, by D. B. H. classes, with corresponding diameters of the average 4-foot stick in the tree or in the stack.*

| Diameter breast-high. | Chestnut. | | Black oaks. | | White oaks. | |
|---|---|---|---|---|---|---|
| | Diameter average stick. | Cubic feet per cord. | Diameter average stick. | Cubic feet per cord. | Diameter average stick. | Cubic feet per cord. |
| *Inches.* | *Inches.* | | *Inches.* | | *Inches.* | |
| 1 | 0.9 | | | | | |
| 2 | 1.8 | 63 | 1.8 | 63 | 1.8 | 63 |
| 3 | 2.6 | 70 | 2.5 | 69 | 2.5 | 69 |
| 4 | 3.3 | 75 | 3.1 | 74 | 3.1 | 74 |
| 5 | 4.0 | 79 | 3.6 | 77 | 3.5 | 76 |
| 6 | 4.7 | 83 | 4.1 | 80 | 3.9 | 79 |
| 7 | 5.2 | 85 | 4.5 | 82 | 4.2 | 81 |
| 8 | 5.8 | 88 | 4.8 | 84 | 4.5 | 82 |
| 9 | 6.2 | 89 | 5.0 | 85 | 4.7 | 83 |
| 10 | 6.7 | 91 | 5.3 | 86 | 4.9 | 84 |
| 11 | 7.0 | 92 | 5.4 | 86 | 5.0 | 85 |
| 12 | 7.4 | 93 | 5.6 | 87 | 5.1 | 85 |
| 13 | 7.7 | 94 | 5.7 | 88 | 5.2 | 85 |
| 14 | 7.9 | 94 | 5.7 | 88 | 5.2 | 85 |
| 15 | 8.2 | 95 | 5.8 | 88 | 5.3 | 86 |
| 16 | 8.4 | 95 | 5.9 | 88 | 5.4 | 86 |
| 17 | 8.5 | 95 | 5.9 | 88 | | |
| 18 | 8.7 | 95 | 6.0 | 89 | | |
| 19 | 8.9 | 96 | 6.0 | 89 | | |
| 20 | 9.0 | 96 | | | | |
| 21 | 9.2 | 96 | | | | |
| 22 | 9.3 | 96 | | | | |
| 23 | 9.5 | 97 | | | | |
| 24 | 9.6 | 97 | | | | |
| 25 | 9.7 | 97 | | | | |
| 26 | 9.8 | 97 | | | | |
| 27 | 10.0 | 97 | | | | |
| 28 | 10.1 | 97 | | | | |
| 29 | 10.2 | 97 | | | | |
| 30 | 10.3 | 97 | | | | |
| 31 | 10.4 | 97 | | | | |
| 32 | 10.6 | 98 | | | | |

## LUMBER.

The volume tables for lumber are based on the diameters inside bark and length of logs cut from trees of various sizes. Scaling was done by the International rule,[1] reduced 10 per cent to allow for the wide kerf cut by the circular saw of the average portable sawmill. The volume in cubic feet left in topwood and branches after logs have been removed is also given. This may be reduced to cords by dividing by 80, a conservative factor. In practice it is best to total the cubic feet remaining per acre before reducing to cords, rather than attempt the reduction for individual trees.

[1] This rule is described and printed in H. S. Graves's Forest Mensuration, pp. 35-38, and in Austin Cary's Manual for Northern Woodsmen, pp. 137 and 232.

TABLE 42.—*Volume of chestnut in lumber.*

| Diameter breast-high. | Height of tree—feet. | | | | | | | | | | Diameter (inside bark) of top. | Basis. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 50 | | 60 | | 70 | | 80 | | 90 | | | |
| | Volume. | | | | | | | | | | | |
| | Lumber. | Topwood. | Lumber. | Topwood. | Lumber. | Topwood. | Lumber. | Topwood. | Lumber. | Topwood. | | |
| *Inches.* | *Bd. ft.* | *Cu. ft.* | *Bd. ft.* | *Cu. ft.* | *Bd. ft.* | *Cu. ft.* | *Bd. ft.* | *Cu. ft.* | *Bd. ft.* | *Cu. ft.* | *Ins.* | *Trees.* |
| 9 | 10 | 5.8 | 15 | 6.9 | 22 | 8.0 | ..... | ..... | ..... | ..... | 7 | 5 |
| 10 | 26 | 5.2 | 32 | 6.2 | 40 | 7.1 | 48 | 6.9 | 56 | 6.6 | 7 | 4 |
| 11 | 42 | 4.9 | 50 | 6.2 | 58 | 7.2 | 69 | 7.2 | 80 | 7.0 | 8 | 9 |
| 12 | 58 | 4.8 | 68 | 6.1 | 78 | 7.3 | 92 | 7.5 | 107 | 7.7 | 8 | 9 |
| 13 | 74 | 4.7 | 87 | 6.1 | 100 | 7.5 | 116 | 7.6 | 133 | 7.8 | 8 | 11 |
| 14 | 92 | 4.6 | 107 | 6.2 | 122 | 7.6 | 141 | 8.4 | 160 | 8.6 | 8 | 17 |
| 15 | 110 | 4.9 | 127 | 6.6 | 147 | 8.2 | 168 | 9.0 | 190 | 9.8 | 9 | 6 |
| 16 | 129 | 5.1 | 150 | 6.9 | 172 | 8.7 | 196 | 10.0 | 222 | 11.3 | 9 | 14 |
| 17 | ..... | ..... | 174 | 6.9 | 200 | 9.3 | 226 | 11.2 | 255 | 13.5 | 9 | 6 |
| 18 | ..... | ..... | 198 | 6.9 | 227 | 10.0 | 257 | 12.6 | 291 | 15.0 | 10 | 11 |
| 19 | ..... | ..... | 223 | 6.9 | 257 | 10.4 | 292 | 13.6 | 328 | 17.0 | 10 | 6 |
| 20 | ..... | ..... | 250 | 7.1 | 288 | 11.6 | 327 | 15.2 | 368 | 19.2 | 10 | 4 |
| 21 | ..... | ..... | 276 | 7.9 | 318 | 12.5 | 363 | 16.8 | 409 | 21.4 | 11 | 3 |
| 22 | ..... | ..... | 305 | 7.9 | 350 | 13.8 | 400 | 19.1 | 451 | 23.7 | 11 | 4 |
| 23 | ..... | ..... | 333 | 8.5 | 385 | 15.2 | 440 | 21.3 | 493 | 27.0 | 11 | 5 |
| 24 | ..... | ..... | 363 | 9.2 | 420 | 16.8 | 479 | 24.3 | 538 | 31.0 | 12 | 2 |
| 25 | ..... | ..... | 396 | 9.7 | 457 | 18.7 | 520 | 27.2 | 583 | 35.8 | 12 | 2 |

Ten per cent deducted for circular saw kerf.

NOTE.—The volume in "topwood" (top and branches) was obtained by subtracting the aggregate cubic volume of sawlogs to a top diameter of 6 inches, inside bark, from the total used volume of the tree, in cubic feet (to a minimum diameter of 2 inches, outside bark).

TABLE 43.—*Volume of red, black, and scarlet oaks in lumber.*

| Diameter breast-high. | Height of tree—feet. | | | | | | | | Diameter (inside bark) of top. | Basis. |
|---|---|---|---|---|---|---|---|---|---|---|
| | 50 | | 60 | | 70 | | 80 | | | |
| | Volume. | | | | | | | | | |
| | Lumber. | Topwood. | Lumber. | Topwood. | Lumber. | Topwood. | Lumber. | Topwood. | | |
| *Inches.* | *Bd. ft.* | *Cu. ft.* | *Bd. ft.* | *Cu. ft.* | *Bd. ft.* | *Cu. ft.* | *Bd. ft.* | *Cu. ft.* | *Inches.* | *Trees.* |
| 9 | 14 | 6.4 | 17 | 8.0 | 21 | 9.6 | ..... | ..... | 7 | 16 |
| 10 | 24 | 6.8 | 30 | 8.2 | 38 | 9.7 | 49 | 10.5 | 7 | 24 |
| 11 | 35 | 7.5 | 45 | 8.8 | 56 | 9.8 | 68 | 10.5 | 8 | 35 |
| 12 | 48 | 8.5 | 60 | 9.4 | 75 | 10.2 | 89 | 10.6 | 8 | 33 |
| 13 | 62 | 10.1 | 77 | 10.8 | 94 | 10.9 | 113 | 10.9 | 8 | 30 |
| 14 | 78 | 11.4 | 96 | 11.9 | 117 | 11.9 | 140 | 11.7 | 9 | 13 |
| 15 | 95 | 12.9 | 117 | 13.3 | 141 | 13.0 | 168 | 12.1 | 9 | 12 |
| 16 | 114 | 14.9 | 140 | 15.1 | 168 | 14.2 | 198 | 12.9 | 9 | 5 |
| 17 | ..... | ..... | ..... | ..... | 195 | 15.6 | 229 | 13.4 | 10 | 4 |
| 18 | ..... | ..... | ..... | ..... | 224 | 16.9 | 263 | 13.9 | 10 | 2 |
| 19 | ..... | ..... | ..... | ..... | 254 | 18.7 | 300 | 15.5 | 10 | 1 |

Ten per cent deducted for circular saw kerf.

NOTE.—The volume in "topwood" (top and branches) was obtained by subtracting the aggregate cubic volume of sawlogs to a top diameter of 6 inches, inside bark, from the total used volume of the tree, in cubic feet (to a minimum diameter of 2 inches, outside bark).

TABLE 44.—*Volume of white and chestnut oaks in lumber.*

| Diameter breast-high. | Height of tree—feet. | | | | | | Diameter (inside bark) of top. | Basis. |
|---|---|---|---|---|---|---|---|---|
| | 50 | | 60 | | 70 | | | |
| | Volume. | | | | | | | |
| | Lumber. | Topwood. | Lumber. | Topwood. | Lumber. | Topwood. | | |
| *Inches.* | *Bd. ft.* | *Cu. ft.* | *Bd. ft.* | *Cu. ft.* | *Bd. ft.* | *Cu. ft.* | *Inches.* | *Trees.* |
| 9 | 18 | 6.3 | 23 | 7.7 | 30 | 9.2 | 7.4 | 1 |
| 10 | 29 | 6.3 | 36 | 7.8 | 47 | 9.4 | 7.7 | 8 |
| 11 | 41 | 6.3 | 50 | 8.1 | 66 | 9.4 | 8.0 | 13 |
| 12 | 56 | 6.3 | 66 | 8.2 | 85 | 9.5 | 8.3 | 1 |
| 13 | 72 | 6.1 | 84 | 8.5 | 107 | 9.7 | 8.6 | 2 |
| 14 | 90 | 6.1 | 104 | 8.6 | 130 | 9.9 | 8.9 | 1 |
| 15 | ..... | ..... | 126 | 8.9 | 156 | 10.3 | 9.1 | ..... |
| 16 | ..... | ..... | 149 | 9.4 | 180 | 10.8 | 9.4 | ..... |

Ten per cent deducted for circular saw kerf.

NOTE.—The volume in "topwood" (top and branches) was obtained by subtracting the aggregate cubic volume of sawlogs to a top diameter of 6 inches, inside bark, from the total used volume of the tree, in cubic feet (to a minimum diameter of 2 inches, outside bark).

## TIES.

Tables are for first-class ties only. They are based on the measurements described under "Lumber," converted into ties by applying data contributed by Mr. T. S. Bristol and Prof. R. C. Hawley, on the tactual mill run, in ties, of logs of various sizes. The cubic fee remaining in the topwood may be converted into cords as described under "Lumber."

TABLE 45.—*Volume of chestnut in ties.*

| Diameter breast-high. | Height of tree—feet. | | | | | | | | | | Basis. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 50 | | 60 | | 70 | | 80 | | 90 | | |
| | Volume. | | | | | | | | | | |
| | Ties. | Top-wood. | Ties. | Top-wood. | Ties. | Top-wood. | Ties. | Top-wood. | Ties. | Top-wood. | |
| *Inches.* | *No.* | *Cu. ft.* | *No.* | *Cu. ft.* | *No.* | *Cu. ft.* | *No.* | *Cu. ft.* | *No.* | *Cu. ft.* | *Trees.* |
| 10 | 1 | 9.0 | 1 | 10.3 | 1 | 11.1 | 1 | 10.5 | 3 | 9.5 | 4 |
| 11 | 1 | 8.2 | 1 | 9.6 | 2 | 10.7 | 2 | 10.4 | 4 | 9.8 | 9 |
| 12 | 2 | 7.5 | 2 | 9.0 | 3 | 10.4 | 3 | 10.3 | 4 | 10.1 | 9 |
| 13 | 3 | 6.9 | 3 | 8.3 | 3 | 9.7 | 4 | 10.0 | 5 | 10.2 | 11 |
| 14 | 3 | 6.2 | 3 | 7.8 | 5 | 9.4 | 5 | 10.0 | 8 | 10.3 | 17 |
| 15 | 5 | 6.1 | 5 | 7.6 | 5 | 9.3 | 6 | 10.0 | 9 | 10.7 | 6 |
| 16 | 6 | 6.0 | 6 | 7.2 | 7 | 9.1 | 7 | 10.2 | 9 | 11.2 | 14 |
| 17 | ..... | ..... | 6 | 6.7 | 8 | 9.0 | 8 | 10.7 | 10 | 12.7 | 6 |
| 18 | ..... | ..... | 7 | 5.9 | 8 | 9.2 | 9 | 11.5 | 11 | 13.5 | 11 |
| 19 | ..... | ..... | 7 | 5.6 | 8 | 9.2 | 10 | 12.1 | 12 | 15.3 | 6 |
| 20 | ..... | ..... | 8 | 5.1 | 10 | 9.9 | 11 | 13.5 | 13 | 17.3 | 4 |
| 21 | ..... | ..... | 9 | 5.1 | 10 | 10.3 | 11 | 14.7 | 14 | 19.4 | 3 |
| 22 | ..... | ..... | 11 | 4.5 | 10 | 10.9 | 14 | 16.8 | 17 | 21.8 | 4 |
| 23 | ..... | ..... | 12 | 4.4 | 12 | 11.8 | 14 | 18.8 | 17 | 25.2 | 5 |
| 24 | ..... | ..... | 12 | 4.7 | 13 | 13.2 | 15 | 21.6 | 19 | 29.1 | 2 |
| 25 | ..... | ..... | 15 | 4.9 | 15 | 14.8 | 18 | 24.4 | 21 | 34.0 | 2 |

All first-class ties, 6 by 8 inches by 8 feet.

NOTE.—The volume in "topwood" (top and branches) was obtained by subtracting the aggregate cubic volume of tie logs to a minimum top diameter of 9 inches, outside bark, from the total used volume of the tree, in cubic feet (to a minimum diameter of 2 inches, outside bark).

TABLE 46.—*Volume of red, black, and scarlet oaks, in ties.*

| Diameter breast-high. | Height of tree—feet. | | | | | | | | Basis. |
|---|---|---|---|---|---|---|---|---|---|
| | 50 | | 60 | | 70 | | 80 | | |
| | Volume. | | | | | | | | |
| | Ties. | Topwood. | Ties. | Topwood. | Ties. | Topwood. | Ties. | Topwood. | |
| *Inches.* | *No.* | *Cu. ft.* | *No.* | *Cu. ft.* | *No.* | *Cu. ft.* | *No.* | *Cu. ft.* | *Trees.* |
| 10 | 1 | 8.4 | 1 | 10.8 | 1 | 12.9 | 1 | 15.0 | 24 |
| 11 | 1 | 9.0 | 1 | 10.8 | 2 | 12.6 | 2 | 14.2 | 35 |
| 12 | 2 | 9.8 | 2 | 11.1 | 2 | 12.6 | 3 | 13.1 | 33 |
| 13 | 2 | 11.1 | 2 | 12.2 | 3 | 12.7 | 4 | 12.5 | 30 |
| 14 | 2 | 12.3 | 4 | 13.0 | 5 | 13.1 | 5 | 12.4 | 13 |
| 15 | 4 | 13.7 | 4 | 14.0 | 5 | 13.5 | 7 | 12.2 | 12 |
| 16 | 4 | 15.7 | 4 | 15.3 | 6 | 14.2 | 7 | 12.1 | 5 |
| 17 | ..... | ..... | ..... | ..... | 7 | 14.6 | 8 | 12.1 | 4 |
| 18 | ..... | ..... | ..... | ..... | 8 | 14.8 | 10 | 11.5 | 2 |
| 19 | ..... | ..... | ..... | ..... | 8 | 15.2 | 11 | 11.8 | 1 |

All first-class ties, 6 by 8 inches by 8 feet.

NOTE.—The volume in "topwood" (top and branches) was obtained by subtracting the aggregate cubic volume of tie logs to a minimum top diameter of 9 inches, outside bark, from the total used volume of the tree, in cubic feet (to a minimum diameter of 2 inches, outside bark).

TABLE 47.—*Volume of white and chestnut oaks in ties.*

| Diameter breast-high. | Height of tree—feet. | | | | | | Basis. |
|---|---|---|---|---|---|---|---|
| | 50 | | 60 | | 70 | | |
| | Volume. | | | | | | |
| | Ties. | Topwood. | Ties. | Topwood. | Ties. | Topwood. | |
| *Inches.* | *No.* | *Cu. ft.* | *No.* | *Cu. ft.* | *No.* | *Cu. ft.* | *Trees.* |
| 10 | 1 | 9.7 | 1 | 11.7 | 1 | 14.1 | 8 |
| 11 | 1 | 9.2 | 1 | 11.5 | 2 | 13.5 | 13 |
| 12 | 2 | 8.9 | 2 | 10.9 | 3 | 12.7 | 1 |
| 13 | 2 | 7.2 | 2 | 9.7 | 3 | 11.7 | 2 |
| 14 | 4 | 5.6 | 4 | 8.7 | 5 | 11.1 | 1 |
| 15 | ..... | ..... | 4 | 8.0 | 6 | 10.6 | ..... |
| 16 | ..... | ..... | 5 | 7.8 | 6 | 10.3 | ..... |

All first-class ties, 6 by 8 inches by 8 feet.

NOTE.—The volume in "topwood" (top and branches) was obtained by subtracting the aggregate cubic volume of tie logs to a minimum top diameter of 9 inches, outside bark, from the total used volume of the tree, in cubic feet (to a minimum diameter of 2 inches, outside bark).

## POLES.

Volumes for chestnut alone are given, since this is at present the only hardwood species accepted for poles. The volumes are based on average taper measurements on the trunks of 75 trees, and are according to the specifications given on page 18. The volume in additional cordwood can be determined approximately from the cubic-foot volumes of topwood in the manner described under "Lumber."

TABLE 48.—*Volume of chestnut in poles.*

| Diameter breast-high. | Height of tree—feet. | | | | | | | | | | Basis. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 50 | | 60 | | 70 | | 80 | | 90 | | |
| | Length of pole. | Volume of top-wood. | Length of pole. | Volume of top-wood. | Length of pole. | Volume of top-wood. | Length of pole. | Volume of top-wood. | Length of pole. | Volume of top-wood. | |
| *Inches.* | *Feet.* | *Cu. ft.* | *Feet.* | *Cu. ft.* | *Feet.* | *Cu. ft.* | *Feet.* | *Cu. ft.* | *Feet.* | *Cu. ft.* | *Trees.* |
| 13 | 25 | 3.5 | 25 | 6.6 | 25 | 9.9 | 25 | 12.0 | 25 | 14.2 | 11 |
| 14 | 30 | 1.4 | 30 | 5.0 | 30 | 8.8 | 30 | 11.4 | 30 | 13.3 | 17 |
| 15 | 35 | ..... | 35 | 3.5 | 35 | 7.7 | 35 | 10.4 | 35 | 12.5 | 6 |
| 16 | ..... | ..... | ..... | ..... | 40 | 6.7 | 40 | 9.2 | 40 | 11.3 | 14 |
| 17 | ..... | ..... | ..... | ..... | 40 | 8.0 | 45 | 8.1 | 45 | 10.6 | 6 |
| 18 | ..... | ..... | ..... | ..... | 45 | 5.0 | 50 | 7.3 | 50 | 9.0 | 11 |
| 19 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | 55 | 8.0 | 6 |
| 20 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | 60 | 7.2 | 4 |

Poles scaled according to specifications given on p. 18.

NOTE.—The volume in "topwood" (top and branches) was obtained by subtracting the cubic volume of the pole from the total used volume of the tree, in cubic feet (to a minimum diameter of 2 inches, outside bark).

## YIELD OF INDIVIDUAL OAK AND OAK-CHESTNUT STANDS.

In the absence of sufficient data for yield tables in lumber and ties for the oak and oak-chestnut types, the following tables which show the actual results of measurements in stands of these types are given. Where two stands were of the same age, their yields were averaged; otherwise no attempt was made to average them. The volume in cords remaining was obtained by dividing the cubic feet remaining by the converting factor in Table 41 corresponding to the average diameter breast-high of the stand.

TABLE 49.— *Yield of selected oak-chestnut plots in lumber and additional cordwood.*

| Age. | Quality I. | | | | | Quality II. | | | | | Quality III. | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Lumber. | Additional cordwood. | Live trees. | Average diameter breast-high. | Basis. | Lumber. | Additional cordwood. | Live trees. | Average diameter breast-high. | Basis. | Lumber. | Additional cordwood. | Live trees. | Average diameter breast-high. | Basis. |
| *Years.* | *Bd. ft.* | *Cords.* | *Number.* | *Inches.* | *Plots.* | *Bd. ft.* | *Cords.* | *Number.* | *Inches.* | *Plots.* | *Bd. ft.* | *Cords.* | *Number.* | *Inches.* | *Plots.* |
| 28 | 1,637 | 35 | 641 | 5.3 | 1 | 120 | 22 | 733 | 4.6 | 1 | | | | | |
| 30 | | | | | | 304 | 23 | 705 | 4.9 | 1 | 56 | 17 | 458 | 5.2 | 1 |
| 32 | | | | | | 474 | 28 | 681 | 5.0 | 1 | | | | | |
| 39 | | | | | | 1,398 | 26 | 606 | 5.4 | 1 | | | | | |
| 40 | | | | | | 1,633 | 31 | 510 | 6.2 | 1 | 60 | 24 | 765 | 4.7 | 1 |
| 44 | | | | | | 1,263 | 22 | 600 | 6.1 | 1 | 741 | 24 | 574 | 5.6 | 1 |
| 45 | | | | | | 1,339 | 33 | 578 | 6.1 | 1 | | | | | |
| 47 | | | | | | | | | | | 382 | 30 | 570 | 5.7 | 1 |
| 50 | | | | | | 7,686 | 27 | 594 | 6.1 | 1 | 1,848 | 22 | 542 | 5.9 | 3 |
| 51 | | | | | | | | | | | 200 | 30 | 649 | 5.5 | 1 |

TABLE 50.— *Yield of selected oak-chestnut plots in ties and additional cordwood.*

| Age. | Quality I. | | | | | Quality II. | | | | | Quality III. | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Ties. | Additional cordwood. | Live trees. | Average diameter breast-high. | Basis. | Ties. | Additional cordwood. | Live trees. | Average diameter breast-high. | Basis. | Ties. | Additional cordwood. | Live trees. | Average diameter breast-high. | Basis. |
| *Years.* | *Number.* | *Cords.* | *Number.* | *Inches.* | *Plots.* | *Number.* | *Cords.* | *Number.* | *Inches.* | *Plots.* | *Number.* | *Cords.* | *Number.* | *Inches.* | *Plots.* |
| 28 | 40 | 28 | 641 | 5.3 | 1 | | | | | | | | | | |
| 39 | | | | | | 36 | 28 | 606 | 5.4 | 1 | | | | | |
| 40 | | | | | | 32 | 35 | 510 | 6.2 | 1 | | | | | |
| 44 | | | | | | 40 | 34 | 600 | 6.1 | 1 | 8 | 27 | 574 | 5.6 | 1 |
| 45 | | | | | | 20 | 36 | 578 | 6.1 | 1 | | | | | |
| 50 | | | | | | 207 | 33 | 594 | 6.1 | 1 | 45 | 25 | 542 | 5.9 | 3 |

TABLE 51.—*Yield of selected oak plots in lumber and additional cordwood.*

| Age. | Quality I. | | | | | Quality II. | | | | | Quality III. | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Lumber. | Additional cordwood. | Live trees. | Average diameter breast-high. | Basis. | Lumber. | Additional cordwood. | Live trees. | Average diameter breast-high. | Basis. | Lumber. | Additional cordwood. | Live trees. | Average diameter breast-high. | Basis. |
| *Years.* | *Bd. ft.* | *Cords.* | *Number.* | *Inches.* | *Plots.* | *Bd. ft.* | *Cords.* | *Number.* | *Inches.* | *Plots.* | *Bd. ft.* | *Cords.* | *Number.* | *Inches.* | *Plots.* |
| 28 | 520 | 25 | 685 | 4.8 | 1 | | | | | | 104 | 13 | 741 | 4.1 | 1 |
| 30 | 1,645 | 27 | 449 | 6.5 | 2 | | | | | | | | | | |
| 34 | | | | | | | | | | | 175 | 18 | 496 | 5.1 | 1 |
| 39 | | | | | | 108 | 26 | 665 | 5.0 | 1 | | | | | |
| 40 | | | | | | 335 | 25 | 660 | 5.1 | 4 | 104 | 24 | 816 | 5.1 | 1 |
| 44 | | | | | | 1,375 | 24 | 434 | 6.1 | 1 | | | | | |
| 47 | | | | | | 152 | 31 | 562 | 5.7 | 1 | | | | | |
| 48 | | | | | | | | | | | 311 | 21 | 612 | 5.1 | 2 |
| 50 | | | | | | 339 | 31 | 582 | 5.7 | 1 | | | | | |
| 53 | | | | | | 6,877 | 31 | 430 | 7.0 | 1 | | | | | |
| 60 | | | | | | | | | | | 1,237 | 27 | 426 | 6.5 | 2 |

TABLE 52.—*Yield of selected oak plots in ties and additional cordwood.*

| Age. | Quality I. | | | | | Quality II. | | | | | Quality III. | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Ties. | Additional cordwood. | Live trees. | Diameter breast-high. | Basis. | Ties. | Additional cordwood. | Live trees. | Diameter breast-high. | Basis. | Ties. | Additional cordwood. | Live trees. | Diameter breast-high. | Basis. |
| *Years.* | *Number.* | *Cords.* | *Number.* | *Inches.* | *Plots.* | *Number.* | *Cords.* | *Number.* | *Inches.* | *Plots.* | *Number.* | *Cords.* | *Number.* | *Inches.* | *Plots.* |
| 28 | 10 | 26 | 685 | 4.8 | 1 | | | | | | | | | | |
| 30 | 26 | 30 | 449 | 6.5 | 2 | | | | | | | | | | |
| 34 | | | | | | | | | | | 4 | 18 | 496 | 5.1 | 1 |
| 40 | | | | | | 14 | 28 | 685 | 5.2 | 2 | 4 | 24 | 816 | 5.1 | 1 |
| 44 | | | | | | 24 | 27 | 434 | 6.1 | 1 | | | | | |
| 48 | | | | | | | | | | | 8 | 22 | 498 | 5.4 | 1 |
| 50 | | | | | | 8 | 32 | 582 | 5.7 | 1 | | | | | |
| 53 | | | | | | 116 | 33 | 430 | 7.0 | 1 | | | | | |
| 60 | | | | | | | | | | | 20 | 29 | 426 | 6.5 | 2 |